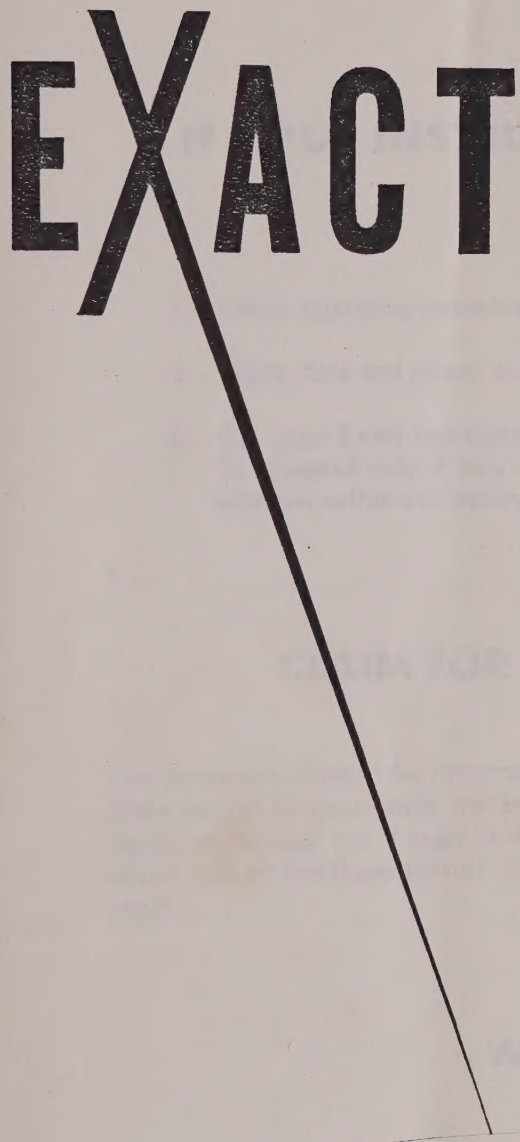
EXACT 500B,
503B, 504B, 505B
WAVE FORM GEN.

ACCOPRESS®

25071	BLACK
25072	LIGHT BLUE
25073	DARK BLUE
25074	LIGHT GRAY
25075	LIGHT GREEN
25076	DARK GREEN
25077	TANGERINE
25078	RED
25079	EXECUTIVE RED
25070	YELLOW

GENUINE PRESSBOARD

ACCO INTERNATIONAL INC.
CHICAGO, ILLINOIS 60611



ELECTRONICS, INC.

INSTRUCTION MANUAL

MODELS 500B, 503B, 504B, and 505B

WAVEFORM GENERATORS

IF YOUR INSTRUMENT DOES NOT OPERATE

PLEASE

1. Check operating procedure in manual for proper setup.

2. Check fuse and power supply voltages.

3. Call your Exact representative or factory. Instruments returned to the factory will be accepted only if they are sent freight prepaid, unless Exact or factory representative has authorized otherwise.

CLAIM FOR DAMAGED SHIPMENT

The instrument should be inspected as soon as received. If damage has occurred, a claim should be made with the carrier. The claim agent should receive a complete report of damage and a copy sent to Exact. After receiving this report, Exact will advise you of the dispostion of the instrument and arrange for its repair or replacement.

WARRANTY

Exact warrants its instruments to be free from defects in material and workmanship under normal use for a period of twelve months from the original date of shipment. Exact's obligation is limited to repair or replacement.

All repairs and replacements made under this warranty are f.o.b. Exact's factory or designated service depot unless otherwise authorized by Exact. This warranty is made on condition that prompt notice of defect is given to Exact, in writing, within the warranty period and that Exact shall have the sole right to determine whether in fact a defect exists.

This warranty does not apply to any instrument which has been repaired or altered by other than Exact's own service representative so as, in Exact's judgment, to adversely affect it, nor which has been subject to misuse, negligence or accident or which has been operated contrary to sound practice or operating instructions.

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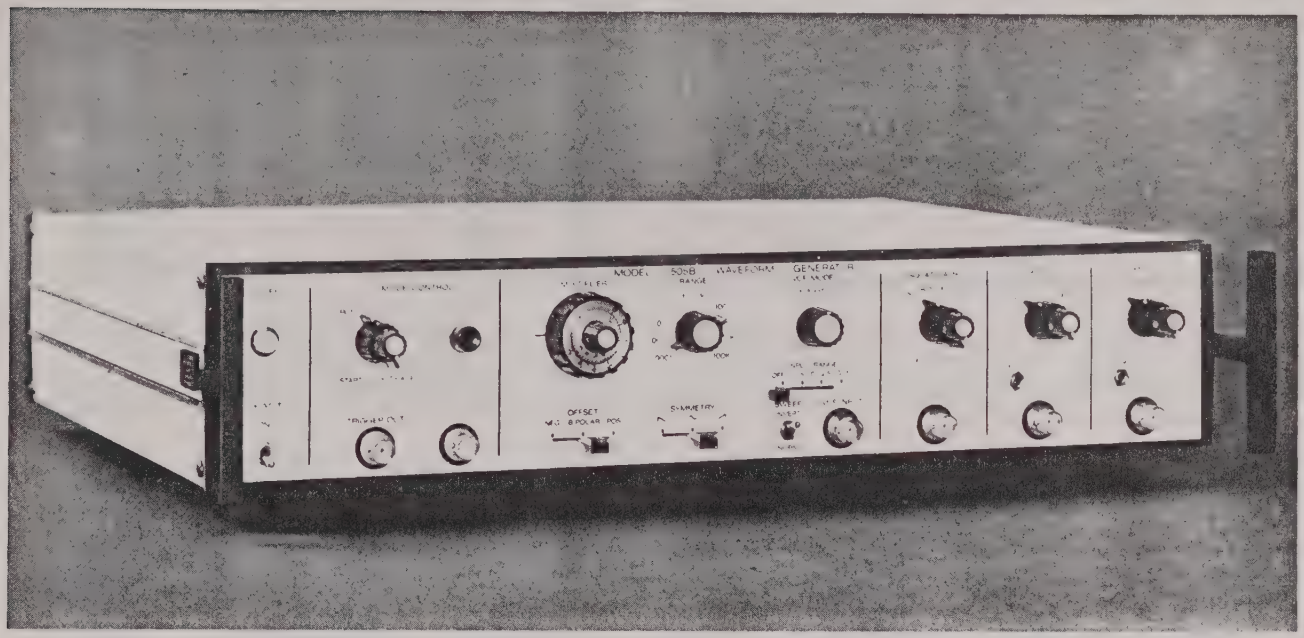
SPECIFICATIONS

500 SERIES WAVEFORM GENERATORS



FEATURES

- INTEGRATED CIRCUITS
- WIDE FREQUENCY RANGE
- HIGH OUTPUT VOLTAGE
- FULL FLOATING OUTPUT PROVISION
- THREE VARIABLE OUTPUT AMPLIFIERS
- PUSH-PULL ANY WAVEFORM
- VCF 50:1, USABLE 100:1
- FIXED OFFSETS, POS. OR NEG FROM GROUND
- ±4V ADJUSTABLE D.C. OFFSET
- GATING AND TRIGGERING (SINGLE SHOT)
- VARIABLE START/STOP PHASE
- 3½" THIN

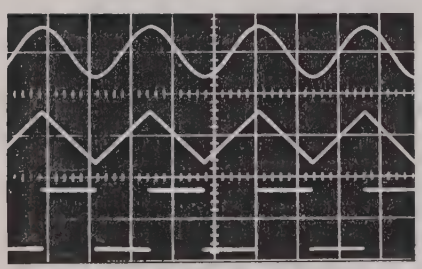


Photo showing phase relationship of square, triangle and sine. Scope: Tektronix 544 with 1A1 Plug-in. Generator frequency 100KHz. All models.

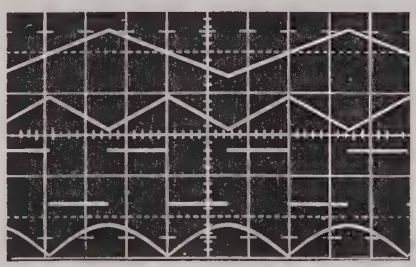


Photo showing symmetrical triangle (upper wave form) with positive offset triangle, square and sine. All models.

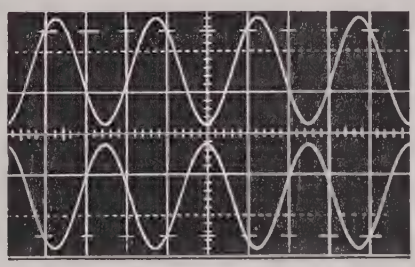


Photo showing 180° phase shift between Amp 1 and Amp 2. Useful for push-pull applications. Amplifiers have capability of in phase outputs also. All models.

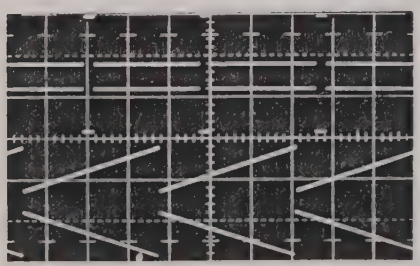


Photo showing 30 °Nano. Sec. rise time sq. pulse with positive offset Forward and Reverse ramp. Ramp frequency excluding fall time is twice that of dial settings. All models.

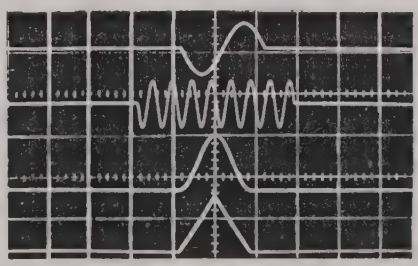
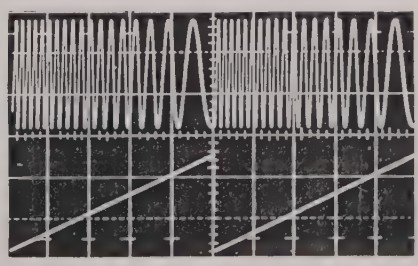


Photo showing triggering (single shot), gating, haversine and havertriangle. 504B and 505B only.



Voltage controlled Frequency — sweeping range 50:1, usable 100:1. 503B and 505B only.

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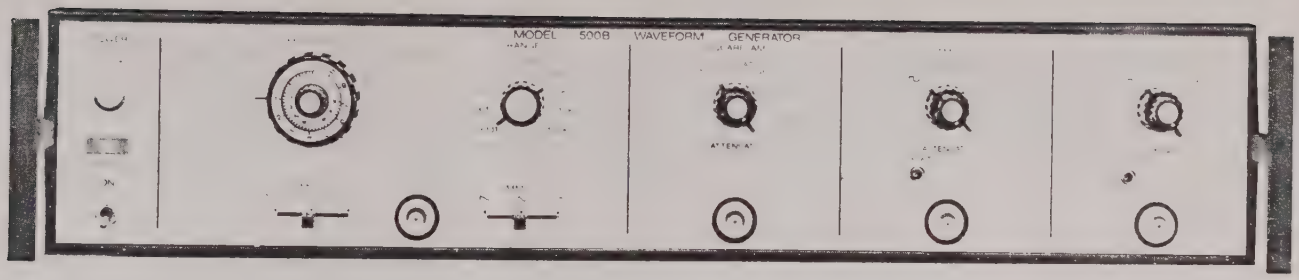
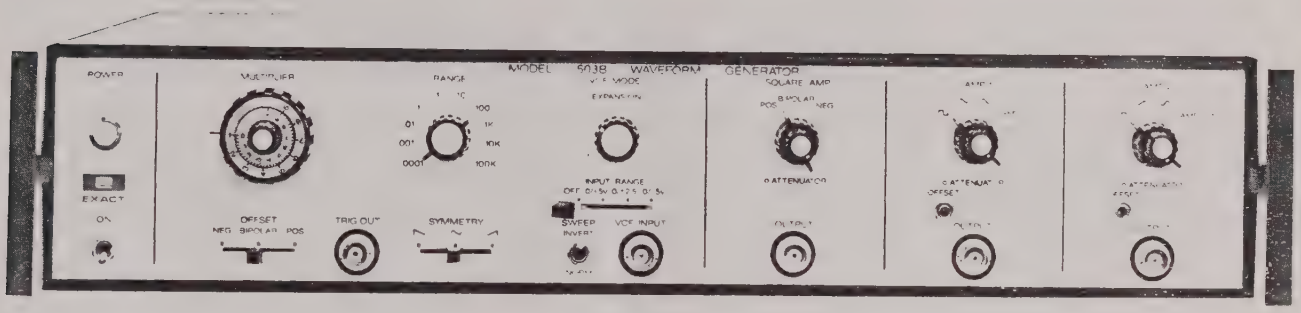
Box 160 Hillsboro, Oregon
97123 · Tel. (503) 648-6661

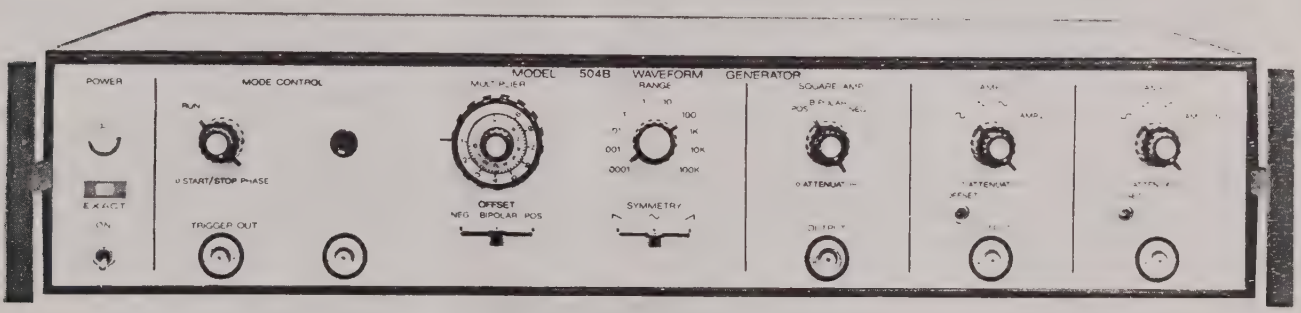


Model 500B — Free running ∿ ⩘ ⊓ ◿ ◺ ⩍ ⊓⊓ generator with the following Features:

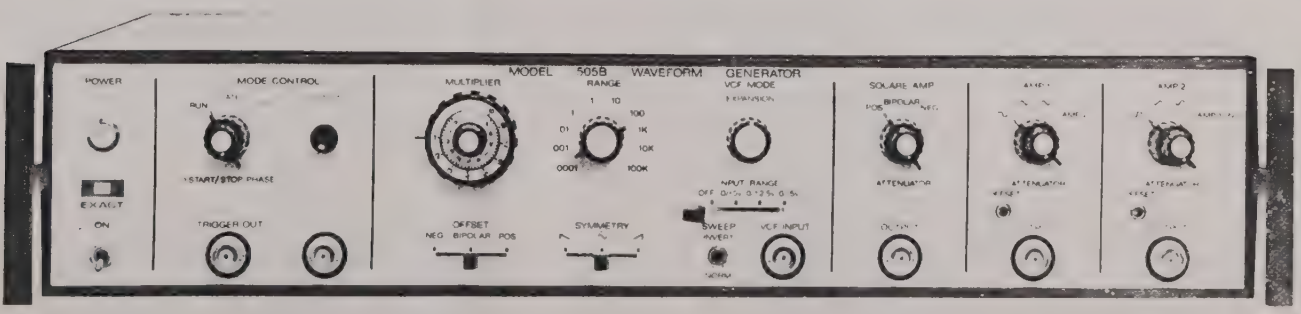
- 0.0001Hz to 1MHz frequency range
- Three simultaneous variable output amplifiers
- Fixed offset positive or negative from ground
- Variable ±4V D.C. offset



Model 503B — Model 500B features plus voltage controlled frequency



Model 504B — Model 500B features plus gating and triggering (single shot)



Model 505B — Model 500B features plus voltage controlled frequency, gating and triggering

GENERAL

APPLICATIONS

The Series 500 was designed to give a great amount of versatility and to provide the functions of many different instruments such as square wave generator, sine wave oscillator, sweep generator, FM modulator, variable repetition rate pulse generator, ramp and raster generator, stimulation and simulation in medical research, control signals for aerospace and environmental test. In general, Exact's waveform generators are ideally suited where signals from biological to radio frequencies are required.

WIDE FREQUENCY RANGE (all models)

Provides frequencies from 0.0001Hz to 1MHz, low capability of 0.00001Hz with VCF function. With Offset switch Pos/Neg, frequency doubles, giving an upper range of 2MHz; Amp 1 and Amp 2 produce waveforms positive or negative-going from ground. The square wave will double in frequency but remain symmetrical about ground. Offset sine will appear as a full wave rectified waveform without filtering (useful in filter testing, see photo).

TRIPLE OUTPUT AMPLIFIERS (all models)

SQ. AMP provides switch selected fast risetime bi-polar or pos/neg square waves from ground, and square pulses by use of Sym switch. Pulse width is fixed and equal to ramp falltime. Repetition rate is variable.

AMP 1 AND 2 are similar. Each provides selection of sine, square, and triangle or ramp and pulse. Amp 1 is non-inverting, while Amp 2 is an inverting amplifier. The two amplifiers provide push-pull outputs automatically with individual amplitude controls. When Amp 2 is in Amp 1 Inv. position, outputs are still push-pull; however now amplitudes of each can be controlled by Amp 1. Amp 2 is then used for balance. This provides a very useful push-pull amplifier with single output amplitude control. When Amp 1 is in Amp 2 position both amplifiers are in phase. Both feature fixed or variable D.C. offset capabilities.

VOLTAGE-CONTROLLED FREQUENCY

MODELS 503B AND 505B offer a precise control of frequency by an external voltage. VCF input signal conditioning allows input voltages of 0 to +5V, 0 to —5V and 0 to ±2½V to be used. The Sweep switch, gives a choice of sweeping up in frequency from 1/50th of dial setting or down in frequency from dial setting, or up and down about a center frequency in the ±2½V position. Center frequency is one-half dial setting. With the 10-turn expansion control, exact sweeping ratio can be set. When using VCF on decade .0001, sweeping ratio is limited to 10:1. This gives a low frequency capability of 0.00001Hz.

GATING AND TRIGGERING

GATING AND TRIGGERING ARE STANDARD ON THE 504B AND 505B. In triggered mode, each input trigger pulse (or each time the manual trigger pushbutton is depressed) generates one complete cycle simultaneously at all outputs. In gated mode, all outputs are generated while the input gate level is present, with automatic last cycle completion when the gate level is removed.

SPECIFICATIONS

SPECIFICATIONS APPLY TO ALL MODELS UNLESS OTHERWISE STATED.

WAVEFORMS

Bipolar—sine, square, triangle, ramp, reverse ramp and pulse. All waveforms with exception of sine can be referenced either positive or negative from ground (sine also, with variable D. C. offset).
Trigger pulse (sync)

Models 504B and 505B add haversine and haver-triangle.

FREQUENCY RANGE

0.0001Hz to 1MHz in ten decade ranges. Square and triangle usable to 2MHz in positive or negative offset. Ramp and pulse usable to 10KHz.
On Models 503B and 505B the VCF function will allow the generator to be swept ten times slower on decades 0.001 and 0.0001. This gives a low frequency capability of 0.00001Hz.

DIAL ACCURACY

±3% of dial reading, typically ±1% to 10KHz, ±2% to 100KHz. Ramp frequency is approximately twice dial setting.

SINE DISTORTION

> .7% to 10KHz
> 1% to 100KHz
> 2% to 1MHz

FREQUENCY STABILITY

Short term: (10 min.) ±0.02%
Long term: (24 hrs.) ±0.2%

AMPLITUDE STABILITY

Short term: (10 min.) ±0.1% of maximum P-P amplitude
Long term: (24 hrs.) ±0.35% of maximum P-P amplitude

SPECIFICATIONS CONTINUED

D. C. REFERENCE STABILITY
Short term: (10 min.) ±0.05% of maximum P-P amplitude
Long term: (24 hrs.) ±0.2% of maximum P-P amplitude

FREQUENCY RESPONSE
Amplitude change with frequency less than 0.1db 0.0001Hz to 100KHz and 0.5db to 1MHz.

SYMMETRY (AMPLITUDE)
Externally adjustable to zero, Amp 1 and Amp 2

SYMMETRY (TIME)
99.5% 0.001Hz to 100KHz, 99% to 1MHz.
95% .0001 decade

SQUARE WAVE RESPONSE
Rise/Fall times
Sq. Amp: < 30nsec
Amp 1: < 50nsec
Amp 2: < 100nsec
Deviation from flatness: < 1%
Overshoot < 5%, typically < 2% of maximum P-P amplitude

TRIANGLE LINEARITY
> 99% 0.0001Hz to 10KHz, > 95% to 1MHz.

RAMP WAVEFORM
Linearity same as triangle to 10KHz. Duration less falltime is equal to twice dial frequency. Falltime is < 10% with exception of decades 100, 1 and .1 which are < 3%.

JITTER (CYCLE TO CYCLE) ±0.02%

SQUARE AMP OUTPUT
Bipolar square: 25V P-P into 600 ohms
Positive square: +12.5V peak into 600 ohms
Negative square: — 12.5V peak into 600 ohms
Output impedance: 50 ohms

AMP 1 OUTPUT
Sine, sq, tri, ramp and pulse: 27V P-P into 600 ohms
Fixed offset pos/neg tri, sq and ramp: +/— 12V peak into 600 ohms
Adjustable D. C. offset ±4V
Output impedance: 12 ohms nominal
Note: Amp 1 can select Amp 2 such that both outputs are in phase. Fixed pos/neg offset waveform frequencies are approximately twice dial setting.

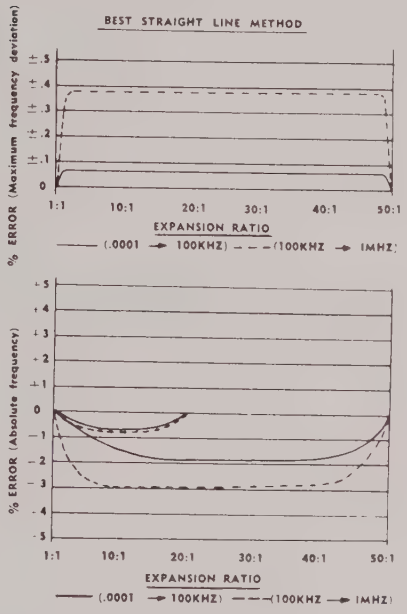
AMP 2 OUTPUT
Output imepdance: 4 ohms nominal
All other outputs and specifications same as Amp 1 with 180° phase shift. Also will select Amp 1 Inverted such that Amp 1 attenuator will control amplitude of both amplifiers.
Useful in push-pull operation.
NOTE: All amplifiers are short-circuit proof and will drive 50 ohms at approximately one-third of specified voltage into 600 ohms.

TRIGGER OUTPUT (SYNC)
Differentiated square waveform
In phase with square wave output
Amplitude (open circuit): ±1.5V peak
Source impedance: 11 ohms

GATE AND TRIGGER MODES (504B, 505B)
Input: D. C. coupled
Input impedance: 10K ohms
Manual or external threshold voltage of approximately +3.2V for turn on. Generator will free run as long as manual or external gate is applied in the Gate position. Threshold voltage must return to near 0V to lock out. In the Trigger position the generator will generate one complete cycle for each manual or external pulse applied.

VOLTAGE-CONTROLLED FREQUENCY (503B, 505B)
Expansion range 50:1, usable to approximately 100:1
Sweep rate: 75 KHz
Inputs: 0 to +5V, 0 to —5V, 0 to ±2½V
Input impedance: approximately 5KΩ
Linearity: (spec'd on 0 to +5V mode only)
0.0001 to 1MHz +0 to —2% 1:1 to 20:1
0.0001 to 100 KHz +0 to —3% 1:1 to 50:1
100KHz to 1MHz +0 to —4% 1:1 to 50:1
(% of absolute frequency not % of Max freq dev. as some function generator manufacturers use.)

VCF LINEARITY CURVE



TEMPERATURE RANGE
Operating, —10°C to +60°C
Storage, —40°C to +80°C
All specifications listed are for +25°C ±5°C
After 30 min warm up

PHYSICAL CHARACTERISTICS
3½" high, 17" wide, 13½". deep (behind panel)
Weight 13 lbs. net, 19 lbs. shipping
Top and bottom covers are easily removable, exposing all calibration and circuit board areas

POWER REQUIREMENTS
Input voltage 115 VAC ±10% or 230 VAC ±10%
Frequency 50 to 400Hz
Power consumption 12 watts

PRICES (FOB HILLSBORO, OREGON)
500B $495.
503B $545.
504B $565.
505B $645.
Overseas prices approximately 5% higher.

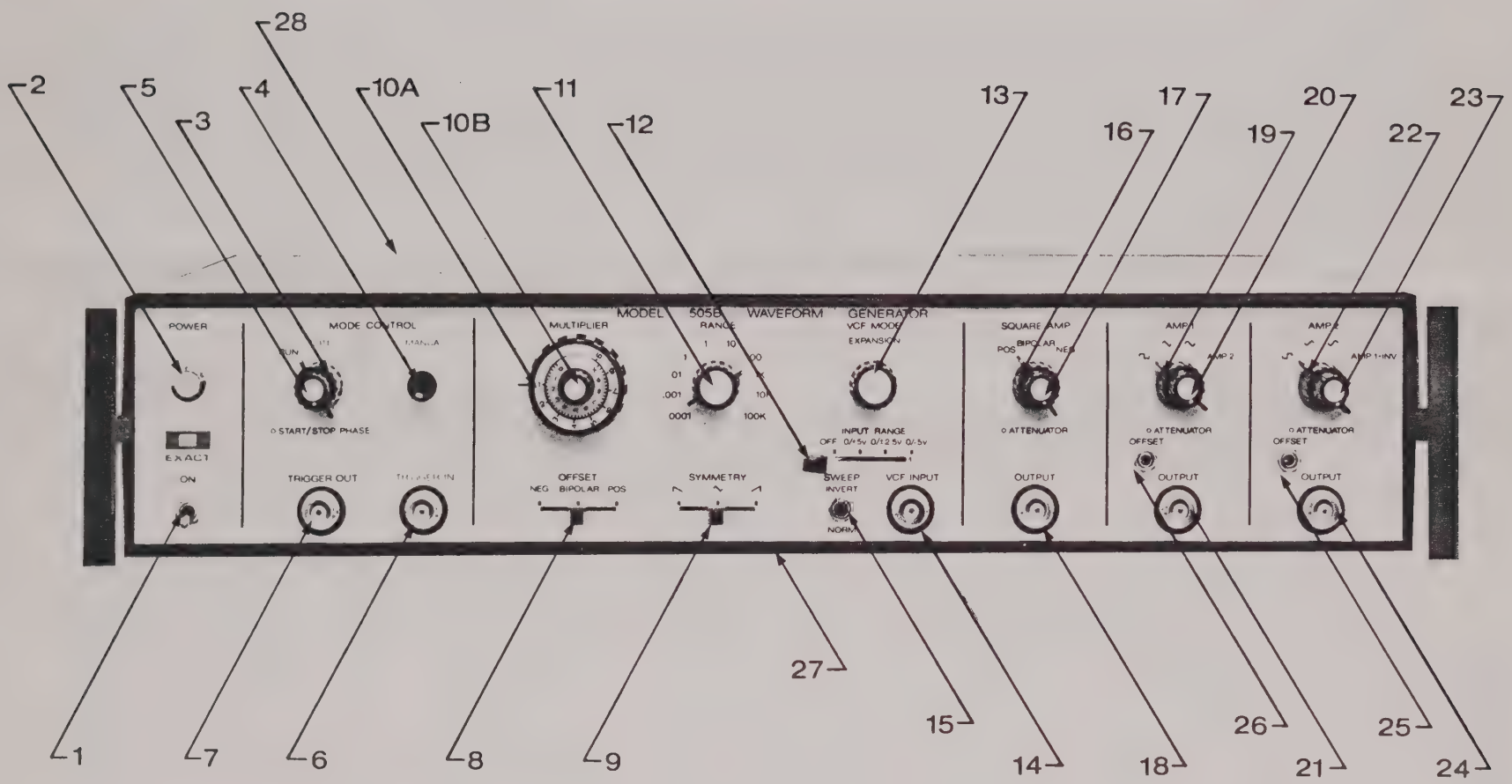
OPTIONS
Rackmounting $10.
Rear outputs (BNC type) $40.
Ten turn attenuators (planetary drive type)
All amplifiers and phase start stop control.
400 M. V. minimum amplitude $25
Special painted front panels (price to be negotiated)

NOTE: All specifications apply 10% to maximum specified voltage amplitude settings.
Due to Exact's continuing policy of product improvement, all specifications and prices are subject to change without notice.

Box 160 Hillsboro, Oregon
97123 Tel. (503) 648-6661
EXACT electronics inc.

SECTION 3

OPERATING INSTRUCTIONS


28
2
5
3
4
10A
10B
11
12
13
16
17
19
20
22
23
MODEL 505B WAVEFORM GENERATOR
POWER
MODE CONTROL
MULTIPLIER
RANGE
VCF MODE
EXPANSION
SQUARE AMP
BIPOLAR
AMP 1
AMP 2
AMP 1-INV
START/STOP PHASE
ATTENUATOR
EXACT
ON
TRIGGER OUT
OFFSET
NEG BIPOLAR POS
SYMMETRY
INPUT RANGE
OFF 0/+5v 0/+12.5v 0/-5v
SWEEP
INVERT
NORM
VCF INPUT
OUTPUT
1
7
6
8
9
27
15
14
18
26
21
25
24

3.1.0 FRONT PANEL FAMILIARITY

3.1.1 LOCATION AND FUNCTION OF CONTROLS

1. Power on/off switch
2. Power ON light indicator
3. Gate/Trigger/Free Run mode selector switch
4. Manual Gate/Trigger pushbutton
5. Variable trigger start-stop adjustment. Varies the start point up to 90°, 45° above 100KHz.
6. External Gate/Trigger input jack
7. External Trigger output jack for triggering external equipment
8. Offset control - provides either positive or negative offset from ground for triangle, ramp or sine out of Amplifiers 1 and 2.
9. Symmetry switch - used to convert triangle into a ramp or square into a pulse.

10A. Digital Multiplier dial - sets first digit of desired frequency

10B. Vernier Multiplier - sets second and third digits of desired frequency

11. Decade selector switch - selects any one of ten decade ranges.
12. VCF input mode selector - selects any of three voltage-controlled frequency inputs. Selection depends on what type of voltage is available.
13. VCF expansion control - variable sweeping range adjustment. Full maximum gives 50:1 sweep with +5V, -5V or ±2½V ramp VCF input.
14. VCF input jack
15. VCF sweep direction selector - selects direction of sweep with any given input voltage. Example, in Norm position with a plus ramp input, generator will sweep down in frequency from dial setting. In the Inv position with same plus input voltage, generator will sweep from low end of sweep range (50:1 lower than dial setting) up to expansion ratio set by expansion control. Refer to Section 3.3.13 for sweep control characteristics when VCF mode selector switch is in the 0 to -5V and 0 to ±2½V positions.
16. Square amp selector - selects bi-polar square, positive square, negative square. Also selects bi-polar pulse, positive pulse and negative pulse if Sym switch is either Pos or Neg.
17. Square Amp attenuator - attenuates output from maximum amplitude down to approximately 200mv.
18. Square Amp output connector
19. Amplifier 1 selector - selects square, triangle, sine or Amplifier 2. Also selects ramp, reverse ramp and pulse if Sym switch is positive or negative. Amp 1 selector to Tri for ramp, Sq for pulse.

3.1.1 LOCATION AND FUNCTION OF CONTROLS (continued)

20. Amplifier 1 attenuator - attenuates outputs from maximum amplitude down to approximately 200mv.

21. Amplifier 1 output

22. Amplifier 2 selector - selects square, triangle, sine or Amp 1 inverted. Also selects ramp, reverse ramp and pulse if Sym switch is Pos or Neg. Amp 1 selector to Tri for ramp, or Sq for pulse.

23. Amplifier 2 attenuator - attenuates from maximum amplitude down to approximately 200mv.

24. Amplifier 2 output connector

25. Amplifier 2 variable ±4V D.C. offset

26. Amplifier 1 variable ±4V D.C. offset

27. Retractable tilt stand

28. Shorting strap - short circuit ground to chassis ground. When removed, all outputs are floating.

3.2.0 FIRST TIME OPERATION

3.2.1 A. Set all function generator controls as follows

POWER	ON
MODE	RUN
OFFSET	NORM
SYMMETRY	TRIANGLE (center)
MULTIPLIER	X10
DECADE	1K
SWEEP	NORM
VCF MODE	OFF
VCF EXPANSION	MAX
SQ AMP	NORM
AMP 1	SQ
AMP 1 ATTEN	MAX
SQ AMP ATTEN	MAX
AMP 2	SQ
AMP 2 ATTEN	MAX
TRIG OUT	Connect trig out jack to monitor oscilloscope external trigger input. Use coaxial cable.

B. Set oscilloscope as follows

VERTICAL SENSITIVITY	5V/CM
INPUT COUPLING	DC
SWEEP TIME	100μSEC/CM
TRIGGER	EXTERNAL POS

3.2.2 PROCEDURE FOR PRODUCING BI-POLAR SQUARE

A. Same settings as in 3.2.1

B. Monitor Square Amp output. Bi-polar square waveforms are also available from Amp 1 and Amp 2 outputs.

3.2.3 PROCEDURE FOR PRODUCING POSITIVE SQUARE

A. Same settings as in 3.2.1 with exception of Sq Amp selector which should be Pos.

B. Monitor Sq Amp output. A positive square is also available out of Amp 1, negative square from Amp 2.

3.2.4 PROCEDURE FOR PRODUCING NEGATIVE SQUARE

A. Same settings as in 3.2.1 with exception of Sq Amp selector which should be Neg.

B. Monitor Sq Amp output. A negative square is also available out of Amp 1, positive square from Amp 2.

3.2.5 PROCEDURE FOR PRODUCING BI-POLAR SQUARE PULSES

A. Same settings as in 3.2.1 with exception of Sym switch which should be in either of the ramp positions. Slide switch full right or left.

B. Monitor Sq Amp output. Bi-polar square pulse is also available from Amp 1 and Amp 2 outputs.

3.2.6 PROCEDURE FOR PRODUCING POSITIVE SQUARE PULSES

A. Same settings as in 3.2.1 with exception of Sym switch which should be in either of the ramp positions, and Sq Amp selector to Pos.

B. Monitor Sq Amp output. Positive square pulse is also available from Amp 1 and Amp 2 outputs.

3.2.7 PROCEDURE FOR PRODUCING NEGATIVE SQUARE PULSES

A. Same settings as in 3.2.1 with exception of Sym switch which should be in either of the ramp positions, and Sq Amp selector to Neg.

B. Monitor Sq Amp output. Negative square pulse is also available from Amp 1 and Amp 2 outputs.

3.2.8 PROCEDURE FOR PRODUCING SINE WAVEFORMS

A. Same settings as in 3.2.1 with exception of Amp 1 and Amp 2 selectors which are set to Sine.

B. Monitor Amp 1 or Amp 2 output. Amp 2 sine will be 180° out of phase with Amp 1.

3.2.9 PROCEDURE FOR PRODUCING TRIANGLE WAVEFORMS

A. Same settings as in 3.2.1 with exception of Amp 1 and Amp 2 selectors which are set to Tri.

B. Monitor Amp 1 or Amp 2 output. Amp 2 triangle will be 180° out of phase with Amp 1.

3.2.10 PROCEDURE FOR PRODUCING RAMP WAVEFORMS

Same procedure and settings as in 3.2.9 with exception of Sym switch which should be in the forward ramp position.

3.2.11 PROCEDURE FOR PRODUCING REVERSE RAMP WAVEFORMS

Same procedure and settings as in 3.2.9 with exception of Sym switch which should be in the reverse ramp position.

3.2.12 PROCEDURE FOR PUSH-PULL OPERATION

Amp 1 and Amp 2 provide push-pull outputs automatically with individual amplitude controls. When Amp 2 is in Amp 1 Inv position, you would still have a push-pull output except that amplitudes of both amplifiers can be controlled by Amp 1 attenuator.

Amp 2 amplitude attenuator is used for balance. For example, if Amp 1 were set to Sine and Amp 2 set to Amp 1 Inv, the unit will produce a push-pull sine output. Amp 1 produces sine at zero degrees while Amp 2 produces sine output at 180 degrees. The attenuator for Amp 2 is now used to match the amplitude of sine waveform out of Amp 1. Adjusting attenuator of Amp 1 will now control amplitude of both waveforms.

3.2.13 VCF OPERATION (Models 503B and 505B only)

A VCF Mode selector switch provides a selection of input voltages depending on what is available. They are 0 to +5V, 0 to -5V and 0 to ±2½V. INPUT MUST MATCH VCF MODE SELECTOR. When used in conjunction with the Sweep switch, the user has a choice of sweeps; he may sweep up in frequency or down in frequency, or up and down about a center frequency in the ±2½V position. Center frequency will be approximately one-half dial setting.

Sweep direction vs input voltage:

1. 0 to +5V position - With sweep switch in Norm position and a zero to plus input voltage, generator will sweep from the dial frequency down to the low end of sweeping range set by expansion control. In Inv position generator frequency will drop to 1/50th of dial setting, then sweep up to a frequency set by expansion control. With expansion control fully CW, generator will sweep up to dial frequency with +5V input. The Inv position requires an external frequency counter to determine exact frequency settings.

2. 0 to -5V position - With sweep switch to Norm the generator will initially drop to approximately 1/50th of dial setting with zero volts input. Precise frequency must be determined with an external frequency counter. When a zero to minus voltage is applied, the generator will sweep up in frequency to an upper frequency which is set by the expansion control. Again, an external frequency counter is required to determine upper frequency.

   With sweep switch to Inv position, generator will sweep from dial setting down to a frequency set by the expansion control.

3. 0 to ±2½V position - When VCF mode switch is set to ±2½V with zero volt input, the generator frequency will drop to approximately one-half of dial setting. With sweep switch set to Norm and a ramp input starting at -2½V, the generator will drop in frequency from the center frequency to the low end of the sweeping range, approximately 1/50th of dial setting. As the ramp goes positive, generator frequency will increase at a linear rate until the input reaches the +2½V peak, at which time the generator will be at approximately dial setting. When the sweep switch is set to Inv the reverse will happen. Exact frequency settings must be determined with an external counter.

3.2.14 GATING, TRIGGERING (single shot) Models 504B and 505B

NOTE: LOCKOUT CIRCUITRY WILL NOT FUNCTION PROPERLY WHEN THE OFFSET SWITCH IS IN THE NEG POSITION.

A. Gating operation (D.C. coupled)

1. Switch Mode selector to Gate.

2. Monitor any output.

3. Push manual Gate/Trig button and observe that the output is present as long as depressed.

4. Once button is released, observe that last cycle is completed before locking out.

5. Using external +5V feeding Ext gate input, observe that generator free runs as long as input is applied.

B. Trigger (single shot) operation (D.C. coupled)

1. Switch Mode selector to Trig.

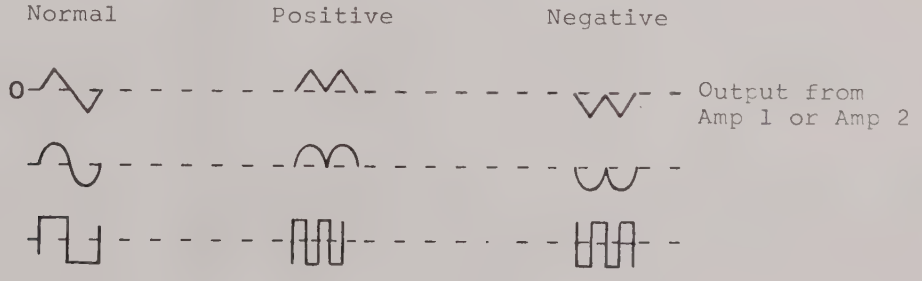
2. Monitor any output.

3. Push manual Gate/Trig button and observe that a single pulse is generated each time button is depressed.

4. Using external source of +5V, feed Ext input, observing that a single pulse is generated for each external trigger input pulse.

3.2.15 OFFSET CONTROL

The following waveforms should be observed, depending upon the position of the offset switch. In the Offset mode, generator frequency will double from the dial setting.



NOTE: Square amplifier output will double in frequency with offset control. However, to offset square amplifier, the square amplifier selector must be used.

SECTION 4

CIRCUIT DESCRIPTION

4.1.0 CIRCUIT DESCRIPTION

4.1.1 BLOCK DIAGRAM (refer to figure 7.1.0, Section 7).

4.1.2 POWER SUPPLY

The regulated power supply produces all operating voltages required by the instrument. It includes regulated ±18V and unregulated ±30V. The power supply is short-circuit protected.

4.1.3 INTEGRATOR

The purpose of the integrator is basically to integrate a square waveform into a linear triangle waveform.

4.1.4 X10 AMP

The X10 Amp is an operational amplifier with a gain variable from 10 to 1. The triangle from the integrator is passed through this amplifier.

This variable gain amplifier causes the triangle amplitude to vary, thus allowing the frequency to be changed.

4.1.5 LEVEL DETECTOR

The function of the Level Detector is to produce a square waveform which is used to connect the + and - VCF supply to the integrator to obtain the triangle waveform.

4.1.6 TIMING AND FEEDBACK CIRCUITRY

The purpose of the timing and feedback circuitry is to connect the integrator and level detector together to make a free-running generator producing square and triangle waveforms plus a method for varying the frequency simultaneously.

The timing circuitry connects the level detector to the integrator circuit. The combination of these circuits produces a free-running oscillator which produces a square waveform and a triangle waveform. The timing circuitry also provides a method of controlling and varying the frequency of the free running oscillator circuit.

4.1.7 SINE SHAPER

The sine shaper is basically an amplifier ultilizing the non-linear characteristics of semoconductor diodes to cause the amplifier gain to vary non-linearly. The triangle waveform is fed into the sine shaper and the resultant sine waveform is produced.

4.1.8 AMP 1 (non inverting)

Amp 1 is basically a high-gain, wide bandwidth amplifier with negative feedback.

4.1.8 AMP 1 (continued)

Any of four inputs (square, triangle, sine or the output of the other amplifier) may be selected. The selected waveform is amplified and applied to the output.

The amplifier will drive 600 ohms at greater than 25V P-P and is short-circuit protected. Output amplitude will vary with load.

4.1.9 AMP 2

Amp 2 is essentially identical to Amp 1 but is inverting.

4.1.10 SQUARE AMPLIFIER

The square amplifier is basically an electronic switch. It is driven by the square waveform from the level detector. The use of such a circuit produces a good square waveform with relatively fast rise and fall times.

Overshoot, ringing and droop are limited by peak clamping of both negative and positive extremes. This amplifier will drive a 600-ohm load at 25V P-P and a 50-ohm load at a lower amplitude. This amplifier is short-circuit protected.

4.1.11 VCF AMPLIFIER

The purpose of the VCF Amp is to provide an equal positive and negative voltage which can be varied simultaneously by the application of an external VCF input voltage (voltage-controlled frequency).

4.1.12 LOCKOUT AMPLIFIER

The purpose of the lockout amplifier is to enable the generator to lock out (stop running). Two lockout modes are provided, gate and trigger. In the gate mode, the generator can be externally or manually gated on as long as signal is applied. In the trigger mode the generator will produce one complete cycle each time a signal is received.

4.2.0 CIRCUIT THEORY OF OPERATION

4.2.1 POWER SUPPLY (refer to figure 7.2.0, Section 7)

The power supply produces ±18V and ±30V to the instrument and consists of two basically identical series regulators which produce a low ripple ±18V from an unregulated ±30V source.

Line voltage is applied to transformer T100 through the on/off switch S100 and fuse F100. The transformer produces 30 volts AC which is fed to rectifier assembly D100 which produces the unregulated ±30V. Capacitors C100 and C110 provide filtering of the unregulated +30V.

Because both the +18V and the -18V regulators are basically identical, only the positive regulator will be discussed here. Q100 is basically a current source. The maximum current is limited by resistor R101.

REGULATOR OPERATION (+18V supply)

A reference voltage of approximately +9V is applied to one side of differential amplifier Q160 and Q180. The reference zener D122 is connected through D121 and voltage divider R123 and R122 to apply approximately +18V on C121 initially to provide a starting voltage for the regulator.

4.2.1 POWER SUPPLY, Regulator Operation (continued)

Q160 will supply current to the base of Q120 which will in turn supply voltage to the base of Q140.

Emitter follower Q140 supplies the regulated +18V. The emitter voltage of Q140 is fed through voltage divider R182, R183 and R184.

The arm of R183 is adjustable and provides approximately +9V at the base of Q180 when Q140 emitter voltage is +18V.

If the output voltage increases due to a decrease in load or an increase in line voltage, the base voltage at Q180 will increase, causing the collector current of Q160 to decrease. The base voltage of Q160 is fixed by zener diode D162 at approximately +9V.

With a decrease in collector current of Q160, voltage at the base of Q120 will increase causing less collector current to flow through Q120 and R124 lowering the voltage at the base of Q140 until the emitter voltage has returned to +18V.

+18V adjust is used to calibrate the power supply to +18V ±3mv. -18V supply operates in essentially the same manner.

4.2.2 INTEGRATOR (refer to figure 7.3.0, Section 7)

The integrator circuit is utilized to produce a very linear output triangle by integrating the square waveform produced by the level detector and the VCF amplifier. The integrator is an operational amplifier.

The operational amplifier Q230 has a matched FET input to obtain a very high input impedance.

Q200 and Q210, matched FET's, provide an extremely high input impedance into the operational amplifier. Feedback from the output emitter follower, Q250 and Q255, is accomplished through the integrating capacitors, C201 through C206, selected by the Decade switch and is also applied to the inverting side of the operational amplifier. This provides negative feedback, forcing the summing junction to remain at virtual ground. The Int Bal control is adjusted to balance the two inputs of the differential operational amplifier.

With the positive VCF supply connected to the timing resistor, the output of the operational amplifier will try to switch negative immediately.

The positive voltage applied to the timing resistor and connected to the summing junction will allow a finite current to flow through the timing resistor. This current will be constant as the VCF voltage is constant and the summing junction is held at virtual ground due to the extremely high gain and negative feedback. Due to the negative feedback through the integrating capacitor, output must charge the integrating capacitor.

As the timing current flows from the summing junction, an equal but opposite current will be applied through the integrating capacitor in the feedback loop. This feedback current through the integrating capacitor must remain constant as the input timing current is constant. This will cause the output to rise negative charging the capacitor at a constant rate.

The output is connected to the level detector through the X10 Amp. When the X10 Amp output reaches a predetermined level, the level detector will change state and invert the square waveform applied to the switching [illegible]

4.2.2 INTREGRATOR (continued)

This will in turn reverse the operation described and the integrator output will reverse and start rising positively, thus producing a linear triangle waveform at the output.

By switching in different timing resistors and integrating capacitors, frequency can be changed in decade steps. By varying the Multiplier dial, the triangle amplitude applied to the integrating capacitors is changed causing a linear change in timing current and thereby changing frequency. By switching resistors and capacitors with the Decade switch and adjusting the Multiplier dial, any desired frequency from 0.0001 to 1MHz may be obtained.

The Sym switch, S560, is provided to produce non-symmetrical operation required for the various non-symmetrical waveforms such as the ramp, reverse ramp and square waveform pulses. Switch S560 enables the VCF voltage to be connected directly to the summing junction, by-passing the timing resistor.

When S560 is switched to the negative position, R575 connects the applied negative VCF voltage directly to the summing junction.

When the positive VCF voltage is connected, the timing resistor will be bypassed by R575, a 10K resistor, causing a much larger timing current to flow. The output of the integrator will rise positive much faster as a result of the increased timing current.

When the output of the X10 Amp reaches the trip point of the level detector the VCF supply will reverse polarity as previously described. With the negative VCF supply now connected, the integrator will integrate at the same rate as in the Norm position.

4.2.3 X10 AMP (refer to figure 7.4.0, Section 7)

The purpose of the X10 Amp is to vary the amplitude of the triangle waveform from the output of the integrator. The amplitude of the triangle waveform from the integrator determines the amount of time required to charge the feedback capacitor. If the amplitude of this triangle changes, the frequency will change.

The X10 Amp is composed of Q260, Q280 and Q290. Q260 is an operational amplifier with a fixed gain of approximately 10.

The output of the X10 Amp is fed through output emitter followers Q280 and Q290 to the input of the level detector. The triangle amplitude at the input of the level detector will remain constant as this is controlled by the level detector trip points.

R261 (multiplier) and R263 form a voltage divider to the input of the operational amplifier. With the arm of the Multiplier control set at maximum (X10), the triangle amplitude at the output of the Integrator will be minimum. A .4V P-P triangle would produce a 4V P-P triangle at the X10 Amp output.

With the Multiplier set at minimum (X1), approximately a 4V P-P triangle waveform will be required to drive the output of the X10 amplifier to 4V P-P. It takes much longer to charge the feedback capacitor to 4V P-P than to .4V P-P. In this manner, the Multiplier in conjunction with the X10 Amp varies the frequency of the generator manually.

4.2.4 LEVEL DETECTOR (refer to figure 7.5.0, Section 7)

The level detector is used in conjunction with the integrator to produce a free-running square and triangle waveform.

The input to the level detector is connected to the output of the X10 Amp. Q300 is a constant current source for differential amplifier Q310 and Q320. Q340 and Q350 form a second differential amplifier which is connected to Q310 and Q320 to form a high-gain amplifier circuit.

The output voltage swing of Q340 and Q350 collectors are both clamped by a diode bridge to approximately ±1.5V P-P.

With the input rising positive, Q310 will turn off and Q320 will turn on. Once Q310 is turned off, the collector voltage of Q310 will go negative. This will in turn cause Q350 base to go negative, causing Q350 to turn off and Q340 to conduct harder. Q340 collector voltage will go farther negative, causing Q320 base to go negative and Q320 to conduct harder. Positive feedback Q350 collector voltage will increase due to Q350 turning off. This in turn causes the output to switch to its positive state.

A positive input waveform causes the output to switch positive when the input trip point is reached (inverting). In this manner, the integrator X10 Amp and the level detector create a free-running square and triangle waveform simultaneously.

Q340 collector signal is applied to the output emitter follower which drives the square amplifier and Q380 which produces the trigger out signal.

4.2.5 SINE SHAPER (refer to figure 7.8.0, Section 7)

The sine shaper is basically a differential operational amplifier with non-linear feedback which will produce a low-distortion sine waveform from a linear triangle input.

Transistors Q600, Q610 and Q620, Q630 are two differential amplifiers connected together to form a high-gain amplifier.

With the input rising at a constant slope (positive triangle), Q630 collector voltage will go negative. As the output rises negatively, the feedback network voltage divider will essentially connect smaller and smaller resistance across the fixed gain feedback resistor R674, thus causing the gain to decrease as the output voltage rises negatively.

When the input triangle changes slope, the output will simply reverse polarity and rise positive, producing the same non-linear action. The constantly changing gain of the amplifier will produce the required sine wave.

Q640 emitter follower and Q650 constant current source provide the necessary current to drive the feedback network. Q660 and Q670 emitter followers provide the moderately low output impedance to drive the associated circuitry.

4.2.6 SQUARE AMPLIFIER (refer to figure 7.10.0, Section 7)

The square amplifier is essentially a high-speed switch which produces a 28V P-P output square waveform at less than 50 nanosecond rise and fall times.

The square waveform from the level detector is fed into the square amplifier input. With the square waveform in its positive state, Q800 will turn on, causing Q800 collector to go negative. This negative signal at Q800

4.2.6 SQUARE AMPLIFIER (continued)

causes Q810 to saturate, thus pulling the collector voltage of Q810 positive very rapidly. The positive input signal will hold Q830 off as long as the input remains positive. When the input switches negative, Q840 collector will switch negative very rapidly.

This square waveform is applied through selector switch S810 to the output emitter follower.

4.2.7 SQUARE SELECTOR SWITCH S810

When switched to the Pos Sq position, a diode is in series with the square waveform being applied to the output emitter follower. This will allow signal to pass in only one direction.

When the selector switch is placed in the Neg Sq position, only the negative portion of the square waveform will pass to the emitter follower and on to the output.

4.2.8 AMP 1, non-inverting (refer to figure 7.11.0, Section 7)

Amp 1 provides the selected waveform at 28V P-P into 600 ohms at the output.

The signal is applied at the input to Amp 1 (TP900). A positive signal will cause Q900 to turn on, driving Q910 collector positive. This amplified signal is applied to output buffer Q920 and Q950 which drive Amp 1 output. The gain is fixed by R941 and R931 to approximately 3.

4.2.9 AMP 2, inverting (refer to figure 7.9.0, Section 7)

Amp 2 also provides the selected waveform at 28V P-P into 600 ohms at the output (inverted).

The signal is applied to the emitters of input transistors Q700 and Q730. Q700 and Q730 bases are grounded.

A positive signal will cause Q700 to turn off. This will cause Q710 to turn off, driving the output negative. This signal is applied to the output buffer Q720 and Q750 which drive the output of Amp 2.

The gain is fixed at approximately 3 as in Amp 1.

4.2.10 VCF AMP (503B and 505B only) (refer to figure 7.6.0)

The VCF Amp provides a ± voltage to the timing resistors which can be varied causing the frequency to change.

Q500 differential amplifier is connected to Q540 to form the positive VCF supply amplifier. Q530 is a constant current source for Q500. With Q500 output base grounded, a positive signal at Q500 input base will cause Q508 input transistor to turn on, driving Q540 base negative and the output positive. Negative feedback (R544, R547) fixes the gain at about 4.

With the input grounded, the output will be approximately 500mv. With a +5V signal at the input, the output will be at +16V. The negative supply is composed of transistors Q550, Q560 and Q580.

A voltage divider (R562, R563 and R581) is connected from the +16V supply to the -16V supply. Base of Q560 will set at about zero volts due to the

4.2.10 VCF AMP (continued)

voltage divider. +16V supply will cause Q560 to turn off driving Q580 base negative, driving output of Q580 negative. When the output reaches -16V, voltage at the base of Q560 will reach zero volts and thus maintain the negative supply at -16V as long as +16V supply remains at +16V. In this manner, the negative supply will track the positive supply and always provide an equal but opposite supply.

As VCF input voltage varies from zero volts to +5V, VCF supply voltages will vary from ±16V to approximately ±500mv.

The VCF mode switch provides three different modes of operation so that the user may operate the VCF with virtually any signal input.

4.2.11 LOCKOUT AMPLIFIER (continued)

GATE MODE

When in the Gate mode of operation, the ground at Q430-Q440 collectors is removed through S400. The flip-flop will remain in the Run state until the positive-going pulse from the square waveform at pin 12 causes Q460 to turn on, reversing the state of the flip-flop. A negative signal is now applied at Q480 base (approximately 0 V DC). As the signal at Q490 base approaches 0 V, Q490 will turn on, causing Q480 to turn off. With Q480 off the lockout diodes become forward biased and the generator will lock out (stop running). By depressing the Man. pushbutton or applying a positive signal at the Ext input, Q400, normally off, will turn on and Q420, normally on, will turn off. The Schmitt (Q400-Q420) will remain in the Run state as long as signal is applied. With Q400 on, approximately 0 V will be applied at Q470. Q470 will remain off as long as signal is applied.

A positive signal from Q420 collector is applied to Q430 base, placing the flip-flop in the Run state.

With Q470 off, Q460 emitter is floating. The signal applied to Q460 base from the square waveform will have no effect until external signal is removed, allowing Q400 to turn off and Q470 on. This will allow the first positive pulse from the square waveform applied to Q460 base to place the flip-flop in the lockout mode again.

The generator will free run as long as external signal remains at the input.

TRIGGER MODE

The function of the lockout amplifier is identically the same as in the Gate mode with the following exception.

Q460 emitter is grounded in the Trig mode through S400. Upon completion of the first cycle, the positive pulse from the square waveform (pin 12) will turn Q460 on, placing the flip-flop in the lockout mode after completion of the first full cycle.

Each time an external signal is applied, one full cycle will be completed. The external signal must be removed before another external signal is applied.

4.2.11 LOCKOUT AMPLIFIER

The Lockout Amplifier is composed of transistors Q400, Q420, Q430, Q440, Q450, Q460, Q470, Q480 and Q490.

4.2.11 LOCKOUT AMPLIFIER (continued)

The input of the X10 Amp (TP260) is connected to the input of differential amplifier Q480-Q490.

The summing junction (TP200) is connected through diodes D484 and D483 to the collectors of Q480. The lockout diodes will be forward biased when Q480 is off and reverse biased when Q480 is on.

As Q490 base rises above Q480 base, Q490 will turn on and Q480 off, forward biasing the lockout diodes. When the lockout diodes become forward biased, the Integrator will stop integrating.

By varying the potential at the base of Q480, it is possible to cause the Integrator to stop at any desired level.

The Lockout D.C. Adj. is used to set the L.O. level at zero volts at the output of the X10 Amp (TP280).

The Start Level control allows the operator to control the level (or phase) at which the generator will start in the Gate and Trigger modes. The level (or phase) may be shifted from the positive extreme to the negative extreme or approximately 90°. The 10K and 100K ranges are limited somewhat as to the amount of offset which may be obtained.

The gating and triggering logic controls the level at the base of Q480.

Q430, Q440, Q450 and Q460 form a flip-flop.

When Q450 and Q460 are in the Off state, a positive signal will be applied at Q480 base. In this condition, Q480 will remain on, reverse biasing the lockout diodes, allowing the generator to free run.

Q400 and Q420 form a Schmitt trigger.

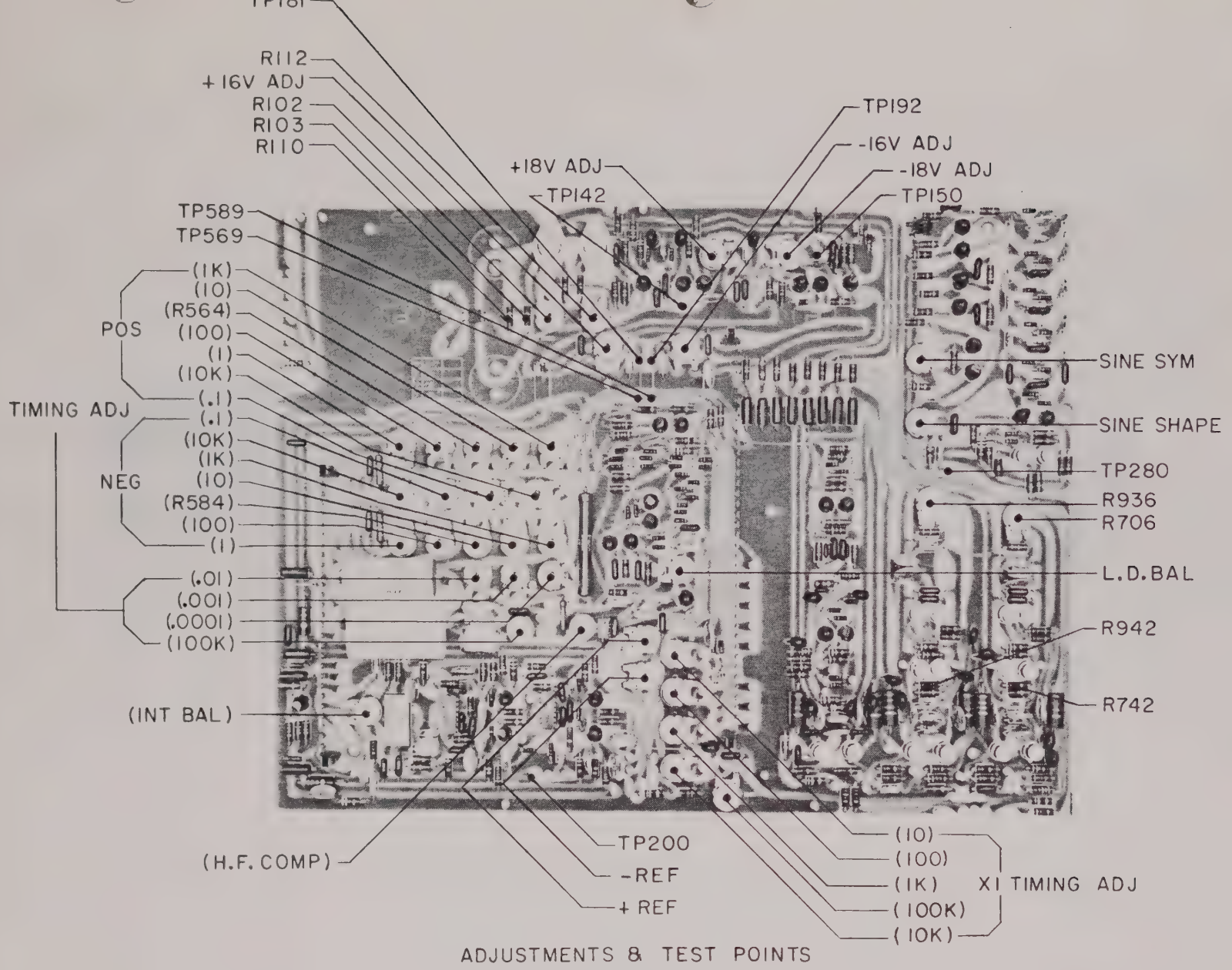
The Manual pushbutton and the Ext input are connected to Q400 base.

RUN MODE

In the Run mode, Q430-Q440 collectors are grounded through S400, causing the flip-flop to remain in the Run state. In this mode, the flip-flop is unaffected by the application of external signal or depressing of the Man. switch.

SECTION 5

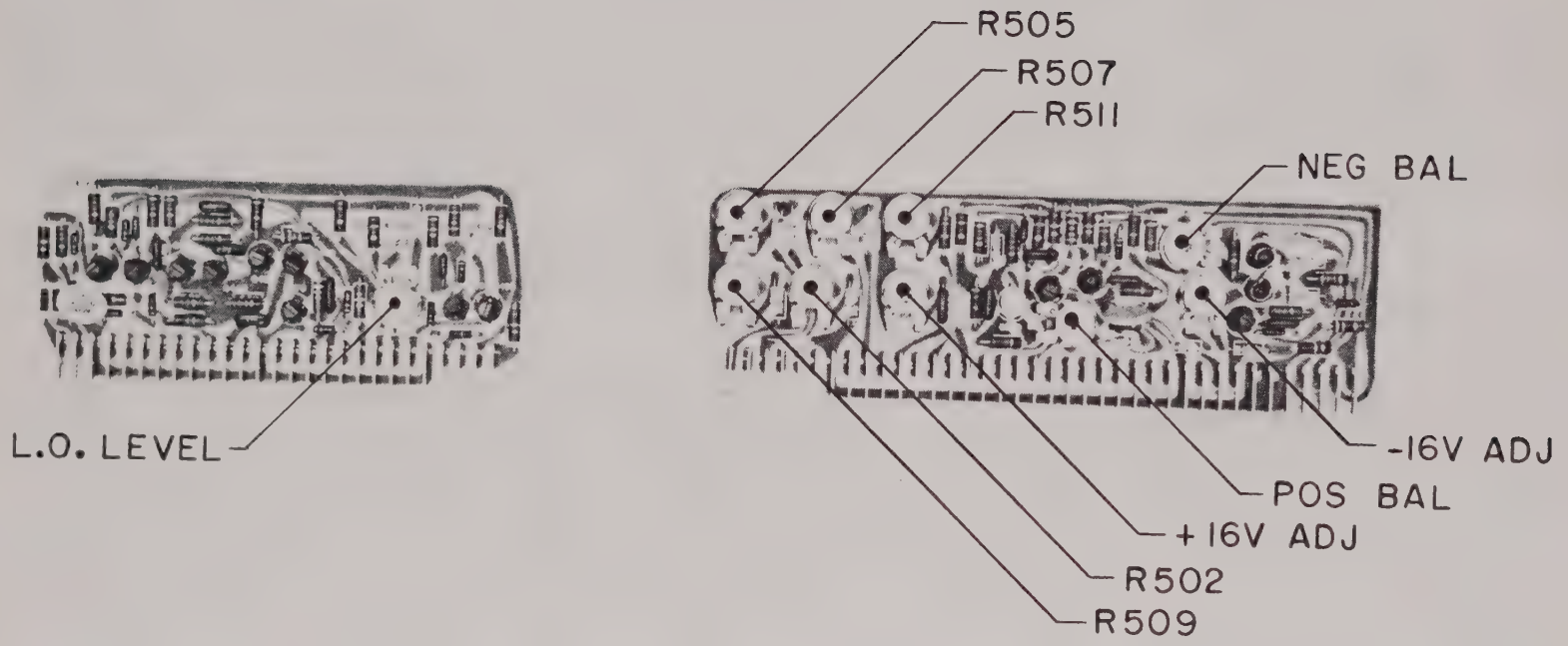
CALIBRATION



ADJUSTMENTS & TEST POINTS

MODEL 505B,504B,503B,500B

FIGURE 5.0.1



ADJUSTMENTS & TEST POINTS

LOCKOUT AMP & VCF AMP

FIGURE 5.0.2

5.1.0 FAILURE TO OPERATE

Read operating instructions to insure a thorough understanding of all front panel controls.

Should instrument fail to have an output from any of three amplifier outputs, check the following.

A. Unplug instrument and check 117V 3AG 1/2 amp fuse, or 3AG 1/4 amp for 220V operation, located on rear panel.

B. Remove cover and check for 117V AC between TP100 and 102. This checks power line cord.

Measure between TP104 and TP107 for 117V AC. This check is for power on/off switch and associated wire. It insures that power is going into power transformer.

If trouble is not located in above steps, follow calibration procedure until trouble is located.

5.2.0 FAILURE TO MEET FACTORY SPECIFICATIONS

Check the following

A. Proper operating instructions in Section 3 to insure a thorough understanding of all front panel controls.

B. Perform all steps of calibration procedure. If instrument still does not meet specifications, contact factory and arrange to return for a complete check-out and evaluation.

5.3.0 CALIBRATION PROCEDURE

The following test equipment or suitable equivalents of known accuracy are required for complete calibration of the Models 500B, 503B, 504B and 505B function generators.

A. Oscilloscope, D.C. to 50MHz, Tektronix 547 with 1A1 and W plug-ins

B. Distortion Analyzer, Hewlett Packard 333A

C. Variac Powerstat

D. Frequency Counter, CMC 607A

E. Constant voltage DC source accurate to 1mv

F. Differential voltmeter, Medistor A-75.

G. 600-ohm purely resistive load

H. VOM, Simpson 260

CALIBRATION PROCEDURE APPLIES TO MODELS 500B, 503B, 504B, and 505B unless otherwise indicated.

Before proceeding, set waveform generator controls as follows

MODE	RUN
MULTIPLIER	10
DECADE	1K
VCF	OFF
SYMMETRY	NORM
SWEEP	NORM
OFFSET	NORM

5.3.1 POWER SUPPLY

NOTE: Instrument should be ON for at least thirty minutes before any of the following adjustments is made.

A. With instrument running, monitor the voltage across R103 (2Ω resistor) with VOM.

B. With a jumper lead, short the +18V supply, TP142, to ground. Adjust R102 to obtain 1.2V ±500mv as indicated on VOM and remove short.

NOTE: DO NOT short circuit +18V supply longer than necessary, as damage may occur to Q100.

C. With instrument running, monitor the voltage across R110 (2Ω resistor) with VOM.

D. With a jumper lead, short the -18V supply, TP150, to ground and adjust R112 to obtain 1.2V ±500mv as indicated on VOM and remove short.

NOTE: DO NOT short circuit -18V supply longer than necessary, as damage may occur to Q110.

E. +18V supply calibration: Connect differential voltmeter to +18V supply, TP142. Adjust +18V adjust to obtain +18V ±2mv.

F. -18V supply calibration: Connect differential voltmeter to -18V supply, TP150. Adjust -18V adjust to obtain -18V ±2mv.

G. Line regulation check

1. Connect differential voltmeter to +18V test point, TP142.

2. Using Variac, vary line voltage from 105V to 125V while monitoring supply voltage. Supply voltage should remain constant ±10mv.

3. Connect differential voltmeter to -18V supply, TP150

4. Using Variac, vary line voltage from 105V to 125V while monitoring supply voltage. Supply voltage should remain constant ±10mv.

H. Power supply ripple check

1. Set oscilloscope controls as follows

VERTICAL SENSITIVITY	MAX
INPUT COUPLING	AC
SWEEP TIME	10msec/cm
TRIGGER	LINE

2. Measure 120Hz ripple content of the +18V, TP142, and -18V, TP150, supplies. Ripple on each supply should be less than 5mv.

5.3.2 INTEGRATOR BALANCE

A. Monitor TP280 (X10 Amp output) with oscilloscope.

B. Ground TP200 (summing junction)

C. Adjust Int Bal (R219) until the output level remains near zero volts.

Noise and 60-cycle ripple will be noticed when adjusted properly.

5.3.3 +16V CALIBRATION (Models 500B and 504B only, or 503B and 505B if VCF board is removed and jumpers installed between TP181-TP569 and TP191-TP589. This would be done only if instrument was required to be put in quick operation and the VCF board was defective.

Connect differential voltmeter to +16V supply, TP181. Adjust +16V adjust R188 to obtain +16V ±3mv.

5.3.4 -16V CALIBRATION (same models as in 5.3.3)

Connect differential voltmeter to -16V supply, TP191 or 192. Adjust -16V adjust, R195, to obtain -16V ±3mv.

5.3.5 LEVEL DETECTOR BALANCE

A. Set oscilloscope controls as follows, using a differential plug-in as Tektronix Type W or equivalent.

VERTICAL SENSITIVITY	MAX SENSITIVITY DIFFERENTIAL MODE
INPUT COUPLING	DC
SWEEP TIMING	.1msec/cm
TRIGGER	EXT POS
MONITOR TEST POINT 280 (triangle waveform at X10 Amp output	

B. Set function generator controls as follows

MODE	RUN
MULTIPLIER	10
DECADE	1K
OFFSET	NORM
SYM	NORM

C. While switching the offset switch from Pos to Neg, notice approximately zero volts reference at the peaks of the triangle in Neg and Pos positions.

D. Adjust Level Detector Bal (LD adjust) until these peaks are equally centered about ground ±50mv.

E. Place Offset switch to Norm position.

F. Adjust L.D. Pos and Neg Ref adj. to obtain a +4.2V peak ±50mv and a -4.2V peak ±50mv at TP280.

5.3.6 VCF AMP (Models 503B and 505B only)

A. Check to see that VCF plug-board, 443-111, is inserted and that jumpers between +16V (TP181-TP569) and -16V (TP191-TP589) are removed.

5.3.6 VCF AMP (continued)

B. Set function generator controls as follows

VCF MODE	OFF
SWEEP	NORM
EXPANSION	FULL CW
INPUT VOLTAGE	GROUND

C. Ground Pin 19 on VCF board connector and adjust +VCF balance with differential voltmeter to zero volts at TP569 (+16V supply).

D. Remove ground and adjust +16V adjust (R514) for +16V ±3mv at TP 569 (+16V supply).

E. Adjust -16V Adj (R563) to obtain -16V ±3mv at TP589 (-16V supply).

F. Set function generator controls as follows

VCF MODE	0 to +5V
SWEEP	INV
EXPANSION	FULL CW

G. Adjust -VCF Bal to obtain equal voltages at TP569 and TP589 ±3mv using differential voltmeter.

H. Repeat steps E through G until both conditions are met.

5.3.7 TIMING

A. Set function generator controls as follows

MODE	RUN
DECADE	100
SYM	NORM
VCF MODE	OFF
OFFSET	NORM
SQ AMP	NORM
TRIG OUT TO SCOPE EXT TRIG IN	

B. Monitor Square Amp output with counter.

NOTE: Steps C, D and E are not required for normal calibration, only if the timing potentiometer has been replaced or if steps H through T cannot be met.

C. Remove Multiplier dial and turn multiplier potentiometer full CCW.

D. Monitoring output frequency, turn multiplier pot CW until frequency has increased 7% to 10%.

E. Replace multiplier dial carefully without moving multiplier control shaft and tighten both set screws with "1" on dial skirt directly in line with index mark on front panel.

F. Set Multiplier to 10 and adjust 100 neg adjust and 100 pos adjust to obtain 1KHz ±.5% symmetrical <.5%. Symmetry can be checked with A-B function on a counter or an oscilloscope.

G. Set Multiplier to 1 and adjust (100) X1 timing adjust to obtain 100Hz ±.5%.

5.3.7 TIMING (continued)

H. 100K X10 Timing

1. Set Decade to 100K, Multiplier to X10.

2. Monitor TP280 with oscilloscope. Adjust (H.F. Comp) for a triangle of 8.4V P-P ±100mv.

3. Monitoring square output with counter, adjust 100K timing capacitor for 1MHz ±.5%.

J. Decade 10K X10 Timing

1. Set function generator controls as follows

DECADE	10K
MULTIPLIER	X10
SQUARE AMP	NORM
ATTENUATOR	MAX CW
AMP 1	SQ
ATTENUATOR	MAX CW

2. Connect counter to Sq. Amp.

3. Connect oscilloscope to Amp 1, set scope controls as follows:

TIME/CM	1µSEC
SWEEP MAGNIFIER	X10
TRIG SOURCE	INT
TRIG SLOPE	+

4. Adjust positive and negative 10K timing potentiometers while switching the Trig slope from + to - on scope until the square risetime and square falltime cross the center line of the scope within one-half a major division, while at the same time adjusting for 100KHz ±.5% on counter. This adjusts the square symmetry so that A and B are of equal time ±.5% and frequency is 100K ±.5%.

K. Decade 1K X10 Timing

1. Set function generator Decade to 1K, other controls same as in paragraph J-1.

2. Connect counter to Sq. Amp.

3. Connect oscilloscope to Amp 1 with scope controls same as in J-3.

4. Adjust the positive and negative 1K timing potentiometers while switching the scope Trig Slope from + to - until the square risetime and square falltime cross the center line of the scope within one-half a major division while at the same time adjusting for 10KHz ±.5%. This adjusts the square symmetry so that A and B are of equal time ±.5% and frequency is 10K ±.5%.

L. Decade 100 X10 Timing

1. Set Decade to 100, Multiplier to 10. Connect counter to Sq. Amp.

5.3.7 L. Decade 100 X10 Timing (continued)

2. Set counter to Time function and while adjusting 100 positive and 100 negative timing potentiometers, switch Function knob from A-B to B-A until time is adjusted to one-half of dial frequency. Counter should read 500 and 500). Set counter to Freq. and counter should read 1KHz ±.5%.

M. Decade 10 X10 Timing

1. Set Decade to 10, Multiplier to 10.

2. Connect counter to Sq. Amp.

3. Set counter to Time function and while adjusting 10 positive and 10 negative timing potentiometers, switch Function knob from A-B to B-A until time is adjusted to one half of dial frequency. Counter should read 500 and 500. Set counter to Freq. and check that frequency is 100KHz ±.5%.

N. Decade 1 X10 Timing

1. Set Decade to 1, Multiplier to 10.

2. Connect counter to Sq. Amp.

3. Set counter to Time function and while adjusting 1 positive and 1 negative timing potentiometers, switch function knob from A-B to B-A until time is adjusted to one half of dial setting. Counter should read 500 and 500. Check to see that frequency is 10Hz ±.5%.

P. .1 X10 Timing

1. Set Decade to .1, Multiplier to 10.

2. Connect counter to Sq. Amp.

3. Set counter to Time function and while adjusting .1 positive and .1 negative timing potentiometers, switch Function knob from A-B to B-A until time is adjusted to one-half of dial frequency. Counter should read 500 and 500. Check to see that frequency is 1Hz ±.5%.

Q. Decades .01, .001 and .0001 Timing

1. Set Decade to .01, Multiplier to 10.

2. Connect counter to Sq. Amp.

3. Set counter to Time function and while adjuting .01 positive and .01 negative timing potentiometers, switch Function knob from A-B to B-A until time is adjusted to one-half of dial frequency. Counter should read 500 and 500.

4. Adjust .01 Timing adjust for .1Hz ± .5%.

5. Switch Decade to .001, adjust .001 Timing to .01Hz ±.5%.

6. Switch Decade to .0001. Adjust .0001 Timing to a frequency of .001Hz ±.5%.

5.3.7 TIMING (continued)

R. X1 Timing for Decades 100K, 10K, 1K, 100, 10

1. Switch Decade to 100K, Multiplier to 1. Adjust 100K X1 Timing Adj to 100KHz ±.5% as read on counter.

2. Switch Decade to 10K. Adjust 10K Timing Adj to 10KHz ±.5% as read on counter.

3. Switch Decade to 1K. Adjust 1K Timing Adj to 1KHz ±.5% as read on counter.

4. Switch Decade to 100. Adjust 100 Timing Adj to 100Hz ±.5% as read on counter.

5. Switch Decade to 10. Adjust 10 Timing Adj to 10Hz ±.5% as read on counter.

S. Check the remaining decades on the Multiplier X1 end to insure that frequency is within ±3%. If it is not, repeat steps 3.5.7 N through R.

T. Check Multiplier dial tracking on all decades to insure that tracking is within ±3% of absolute.

5.3.8 VCF MODE CALIBRATION (Models 503B and 505B only)

A. 0 to +5V

1. Set function generator controls as follows

DECADE	1K
MULTIPLIER	10
VCF MODE	0 to +5V
SWEEP	NORM
VCF INPUT VOLTAGE	+5V ±2mv

2. Adjust EXP control to obtain 1/50 of dial frequency, 200Hz ±1%.

3. Set function generator controls as follows

SWEEP	INV
INPUT VOLTAGE	+5V ±2mv

Adjust R507 until the output frequency is within ±.5% of the dial frequency, 10KHz ±.5%.

B. 0 to ±2.5V

1. Set function generator controls as follows

VCF MODE	0 to ±2.5V
SWEEP	NORMAL
EXP	FULL CW
INPUT VOLTAGE	GND

2. Adjust R505 to obtain one-half the dial frequency, 5KHz ±.5%.

3. Set function generator controls as follows

SWEEP	INV
INPUT VOLTAGE	GND

The frequency should be approximately 5% to 15% higher than in Step 2. This is normal.

5.3.8 B. 0 to ±2.5V (continued)

4. Set function generator controls as follows

VCF MODE	0 to ±2.5V
SWEEP	NORM
INPUT VOLTAGE	+2.5V ±3mv

Adjust VCF Expansion control to obtain 200Hz ±1%.

5. Apply -2.5V ±3mv at VCF input. The output frequency should now be within ±2% of dialed frequency, 10KHz.

6. Set function generator controls as follows

VCF MODE	0 to ±2.5V
SWEEP	INV
INPUT VOLTAGE	-2.5V ±3mv

Adjust VCF Expansion control to obtain 200Hz ±1%.

7. Apply +2.5V ±3mv at VCF input. The output frequency should be approximately 10KHz ±.5%.

C. 0 to -5V

1. Set function generator controls as follows

VCF MODE	0 to -5V
SWEEP	INV
EXP	FULL CW
INPUT VOLTAGE	GND

2. Adjust R509 to obtain 10KHz ±.5%.

3. Apply -5V ±3mv at VCF input and adjust R502 for 200Hz ±1%.

4. Set function generator controls as follows

SWEEP	NORM
INPUT VOLTAGE	-5V ±3mv

Adjust Expansion control to obtain 10KHz ±1%.

5. Apply 0 V ±3mv to VCF input and adjust R511 to obtain 200Hz ±1%.

5.3.9 SYMMETRY CONTROL CHECK (no calibration required)

A. Monitor the triangle waveform at TP280 X10 Amp output.

B. Place the Sym switch in the Pos position and note that the ramp rises positive.

C. Place the SYM switch in the Neg position and note that the ramp rises negative.

D. Note that the ramp falltime is less than 10% of the total period of the waveform from .0001Hz to 10KHz.

E. Place Sym switch in Norm position.

5.3.10 OFFSET CONTROL CHECK (no calibration required)

A. Monitor the triangle waveform at TP280 X10 Amp output

B. Place Offset switch in Pos position and note that the frequency is doubled and that the triangle has shifted up 4V and has decreased in amplitude from 8.4V P-P to 4.2V P-P (0 to +4.2V P).

C. Place the Offset switch in the Neg position and note an equal but opposite change (0 to -4.2V P).

5.3.11 LOCKOUT CALIBRATION (Models 504B and 505B only)

A. Insert the Lockout P.C. board, 443-112 and set function generator controls as follows

MODE	GATE
DECADE	100
MULT	10
OFFSET	NORM
SYM	NORM

B. Set the L.O. Level Adj mid-range and adjust level at TP280 (X10 Amp output) to 0 V with start level control on front panel. The start level should vary +4V by adjusting the start level control.

C. Depress the Man. pushbutton and note that the generator will free run as long as the button is depressed.

D. Place the Mode switch in the Trig position and note that the generator will complete one cycle each time the button is depressed.

NOTE: Scope triggering is very critical in order to observe single pulse.

E. Place the Mode switch in the Gate position. Apply an external gating signal of at least +3V. The generator will free run as long as gating signal is present.

NOTE: The external gating or triggering signal must be >+3V to "turn on" and must return to 0 V or less to "turn off."

F. Place the Mode switch in the Trig position. Apply an external signal as in previous step. The generator will complete one cycle each time the signal rises above +3V.

NOTE: As in previous step, the signal must return to 0 V or less before another signal is applied.

G. Set function generator controls as follows

MODE	GATE
DECADE	100K
MULT	10
OFFSET	NORM
SYM	NORM

Apply an external gating signal at a frequency of 990KHz and note that the generator will gate on and off.

H. Repeat previous step in Trig position, again noting that scope triggering is very critical when observing a single pulse.

5.3.12 TRIGGER OUT CHECK

Check trigger output for differentiated square wave of greater than ±1V P open circuit.

5.3.13 SINE SHAPER CALIBRATION

A. Set Decade at 100 and Mult at 10.

B. Monitor the sine distortion at Amp 1 output.

C. Adjust Sine Shape and Sine Sym to obtain minimum distortion as indicated on distortion analyzer, <.6% .0001 to 10KHz, <1% 10KHz to 100KHz, <2% 100KHz to 1MHz.

5.3.14 SQUARE AMP CHECK (no calibration required)

A. Check for greater than 25V P-P square waveform into 600-ohm load.

B. Check negative and positive square for greater than 12.5V into 600 ohms.

C. Check D.C. reference level of 0 V ±100mv.

D. Check risetime and falltime for <50ns.

5.3.15 AMP 1 CALIBRATION

A. Set function generator controls as follows

MODE	RUN
DECADE	100
MULTIPLIER	10
VCF MODE	OFF
OFFSET	NORM
SYM	NORM
SWEEP	NORM
AMP 1 MODE	TRIANGLE
AMP 1 ATTEN	MAX

B. Monitor Amp 1 output.

C. Set Amp 1 attenuator to minimum amplitude, adjust Var Offset (front panel) to obtain 0 V ±50mv.

D. Set Amp 1 for a 28V P-P triangle and adjust R936 to obtain approximately 500 to 700mv voltage drop across R942 as measured with VOM.

E. Check all waveforms for greater than 25V P-P into 600 ohms.

F. Check square waveform rise and fall times for less than 50ns.

G. Check Var Offset for >±4V.

5.3.16 AMP 2 CALIBRATION

A. Set function generator Amp 2 mode to Tri, Amp 2 Atten to Max, other controls as in 5.3.15 A.

B. Monitor Amp 2 output

C. Set Amp 2 attenuator to minimum amplitude and adjust Var Offset (front panel) to obtain 10V ±50mv.

D. Set Amp 2 for a 28V P-P triangle and adjust R706 to obtain approximately 500 to 700mv voltage drop across R742 as measured with VOM.

E. Check all waveforms for greater than 25V P-P into 600 ohms.

F. Check square waveform rise and fall times for less than 105ns.

G. Check Var Offset for >±4V.

SECTION 6 PARTS LIST

Manufacturers

Arco Electronics, Inc.
Manufacturing Div.
Community Drive
Great Neck, New York

Bendix Corporation
Microwave Devices, Inc.
Hurricane Road
Franklin, Indiana

Buckeye Stamping Co.
555 Marion Road
Columbus, Ohio 43207

Carling Electric, Inc.
507 New Park Avenue
W. Hartford, Ct.

Continental Device Corp.
12515 Chaldron Avenue
Hawthorne, California

Dickson Electronics Corp.
Box 1390
Scottsdale, Arizona

Elco Corporation
Maryland Rd & Computer Ave
Willow Grove, Pa.

Electra Midland Corp.
3151 Fiberglas Road
Kansas City, Kansas

Elpac, Inc.
3760 Campus Drive
Newport Beach, Calif.

Erie Technological Prod.
644 West 12th St.
Erie, Pa. 16512

Fairchild Controls
5625 Kearny Villa Rd.
San Diego, California

IRC Div. of TRW, Inc.
Box 887
Burlington, Iowa

Kemet, Comp. Dept
Union Carbide, Inc.
13607 E. Whittier
Whittier, California

Littlefuse, Inc.
800 E. N.W. Highway
Des Plaines, Ill 60016

Mallory, P.R. & Co.
3029 E. Washington
Indianapolis, Indiana

Miller Electric Co.
Box 231
Woonsocket, R.I.

Motorola Semiconductor
P.O. Box 955
Phoenix, Arizona

Ohmite Div.
Allen Bradley Co.
1201 S. Second
Milwaukee, Wisconsin

Penn Resistor Co.
526 N. Broad St.
Lansdale, Pa. 19446

Radio Materials Co.
4242 W. Bryn Mawr Ave.
Chicago, Ill 60646

Raytheon Company
Components Div.
465 Centre St.
Quincy, Mass. 02169

Sangamo Electric Co.
Capacitor Div.
Box 128
Pickens, S.C. 29671

Sartron
114 N. Main
Newberg, Oregon

Stackpole Carbon Co.
Electronic Comp. Div.
St. Marys, Pa. 15857

Texas Instruments, Inc.
Industrial Prod. Div.
Box 66027
Houston, Texas 77006

TRW: See IRC

Union Carbide Corp.
Electronics Div.
Box 5928
Greenville, S.C.

Capacitors

Ckt. Ref.	Description	Exact #	Mfg.	Mfg. #
C100	2500mf 35V elect.	290-034	Sangamo	500-1954-01
C110	2500mf 35V elect.	290-034	Sangamo	500-1934-01
C121	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C141	270pf 500V dip mica	281-540	Arco	DM15-271J
C161	6.8mf 35V elect.	290-043	Dixon	D6R8GB35K
C171	270pf 500V dip mica	281-540	Arco	DM15-271J
C181	.01mf 500V disc.	283-005	RMC	SM-Z5U
C182	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C183	.05 500V disc	283-010	RMC	SM-Z5U
C190	.01mf 500V disc	283-005	RMC	SM-Z5U
C201	8-50pf trimmer	281-022	Erie	557-013-34E
C202	270pf 500V dip mica	281-540	Arco	DM15-271J
C203	.001mf 600V polysty.	290-018	Mallory	SX210
C204	.01mf 600V polysty.	290-019	Mallory	SX110
C205	1mf 100V	290-022	Elpac	B1A105J
C206	10mf 100V	285-213	TRW	X663F
C231	.01mf 500V disc.	283-005	RMC	SM-Z5U
C232	.01mf 500V disc.	283-005	RMC	SM-Z5U
C233	.01mf 500V disc.	283-005	RMC	SM-Z5U
C234	39pf 500V dip mica	381-531	Arco	DM15-390J
C235	68pf 500V dip mica	281-523	Arco	DM15-680J
C236	5pf 500V dip mica	281-501	Arco	DM15-050A
C237	39pf 500V dip mica	281-531	Arco	DM15-390J
C238	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C239	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C250	.01mf 500V disc	283-005	RMC	SM-Z5U
C251	.01mf 500V disc	283-005	RMC	SM-Z5U
C255	.01mf 500V disc	283-005	RMC	SM-Z5U
C256	.01mf 500V disc	283-005	RMC	SM-Z5U
C257	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C258	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C264	.01mf 500V disc	283-005	RMC	SM-Z5U
C265	10pf 500V dip mica	281-529	Arco	DM15-100J
C266	120pf 500V dip mica	281-534	Arco	DM15-121J
C267	.01mf 500V disc	283-005	RMC	SM-Z5U
C269	12pf 500V dip mica	281-541	Arco	DM15-120J
C280	.01mf 500V disc	283-005	RMC	SM-Z5U
C281	.01mf 500V disc	283-005	RMC	SM-Z5U
C291	.01mf 500V disc	283-005	RMC	SM-Z5U
C292	.01mf 500V disc	283-005	RMC	SM-Z5U
C301	.01mf 500V disc	283-005	RMC	SM-Z5U
C311	8-50pf trimmer	281-022	Erie	557-013-34E
C312	47pf 500V dip mica	281-532	Arco	DM15-470J
C350	.01mf 500V disc	283-005	RMC	SM-Z5U
C351	.01mf 500V disc	283-005	RMC	SM-Z5U
C352	.01mf 500V disc	283-005	RMC	SM-Z5U
C353	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C354	.01mf 500V disc	283-005	RMC	SM-Z5U
C361	.01mf 500V disc	283-005	RMC	SM-Z5U
C371	.01mf 500V disc	283-005	RMC	SM-Z5U
C380	68pf 500V dip mica	281-523	Arco	DM15-680J
C381	.01mf 500V disc	283-005	RMC	SM-Z5U
C400	.01mf 500V disc	283-005	RMC	SM-Z5U
C401	.05 50V disc	283-010	RMC	SM-Z5U
C430	100pf 500V dip mica	281-537	Arco	DM15-101W
C440	47pf 500V dip mica	281-532	Arco	DM15-470J
C450	47pf 500V dip mica	281-532	Arco	DM15-470J
C460	12pf 500V dip mica	281-541	Arco	DM15-120J

Ckt. Ref.	Description	Exact #	Mfg.	Mfg. #
C501	270pf 500V dip mica	281-540	Arco	DM15-271J
C502	.05 disc 500V	283-010	RMC	SM-Z5U
C541	68pf 500V dip mica	281-523	Arco	DM15-680J
C542	22pf 500V dip mica	281-530	Arco	DM15-220J
C543	.01mf 500V disc	283-005	RMC	SM-Z5U
C551	.01mf 500V disc	283-005	RMC	SM-Z5U
C581	68pf 500V dip mica	281-523	Arco	DM15-680J
C620	10pf 500V dip mica	281-529	Arco	DM15-100J
C630	10pf 500V dip mica	281-529	Arco	DM15-100J
C641	.01mf 500V disc	283-005	RMC	SM-Z5U
C650	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C651	10pf 500V dip mica	281-529	Arco	DM15-100J
C652	10pf 500V dip mica	281-529	Arco	DM15-100J
C653	82pf 500V dip mica	281-533	Arco	DM15-820J
C670	22pf 500V dip mica	281-530	Arco	DM15-220J
C671	10pf 500V dip mica	281-529	Arco	DM15-100J
C672	22pf 500V dip mica	281-530	Arco	DM15-220J
C702	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C721	.01mf 500V disc	283-005	RMC	SM-Z5U
C724	.01mf 500V disc	283-005	RMC	SM-Z5U
C732	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C751	.01mf 500V disc	283-005	RMC	SM-Z5U
C752	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C754	.01mf 500V disc	283-005	RMC	SM-Z5U
C801	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C802	22pf 500V dip mica	281-530	Arco	DM15-220J
C810	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C811	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C820	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C821	.01mf 500V disc	283-005	RMC	SM-Z5U
C822	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C823	7pf 500V dip mica	281-536	Arco	DM15-070D
C824	8pf 500V dip mica	281-535	Arco	DM15-080D
C825	.01mf 500V disc	283-005	RMC	SM-Z5U
C831	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C832	22pf 500V dip mica	281-530	Arco	DM15-220J
C840	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C841	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C850	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C851	.01mf 500V disc	283-005	RMC	SM-Z5U
C852	7pf 500V dip mica	281-536	Arco	DM15-070D
C853	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C854	.01mf 500V disc	283-005	RMC	SM-Z5U
C855	10pf 500V dip mica	281-529	Arco	DM15-100J
C900	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C902	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C921	.01mf 500V disc	283-005	RMC	SM-Z5U
C922	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C923	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C924	.01mf 500V disc	283-005	RMC	SM-Z5U
C930	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C932	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C951	.01mf 500V disc	283-005	RMC	SM-Z5U
C952	6.8mf 35V tantalum	290-042	Kemet	K6R8C35K
C953	6.8mf 35V tantalum	290-043	Dixon	D6R8GB35K
C954	.01mf 500V disc	283-005	RMC	SM-Z5U
C955	.05mf 50V disc	283-010	RMC	SM-Z5U

Diodes

D110	1N4001 rectifier	152-4001	T.I.	
D161	1N914	152-0914	Raytheon	
D162	1N935A zener	152-0935A	Motorola	
D181	1N4001 rectifier	152-4001	T.I.	
D191	1N4001 rectifier	152-4001	T.I.	
D230	1N5242 12V 5% zener	152-5242	Motorola	
D250	CD1541	152-0541	CDC	
D255	CD1541	152-0541	CDC	
D256	1N5242 12V 5% zener	152-5242	Motorola	
D261	1N914	152-0914	Raytheon	
D262	1N914	152-0914	Raytheon	
D281-291	CD1541	152-1541	CDC	
D311-312-321-322-323-324-				
D341-342-343-344-345-350-				
D351-352	1N914	152-0914	Raytheon	
D353-355	matched			
D354-356	1N914	152-0914	Raytheon	
D357-358	1N752A zener	152-0752A	T.I.	
D359-361-362-363-371	1N914	152-0914	Raytheon	
D400-401-402-403	1N914	152-0914	Raytheon	
D420	1N953A	152-0753A	T.I.	
D421-422-423	1N914	152-0914	Raytheon	
D480-481	1N914	152-0914	Raytheon	
D482	1N953A	152-0935A	Motorola	
D483	1N914	152-0914	Raytheon	
D484	CD1541	152-0541	CDC	
D485	1N914	152-0914	Raytheon	
D501	1N752A zener	152-0752A	Motorola	
D541-542	1N914	152-0914	Raytheon	
D561	1N752A zener	152-0752A	Motorola	
D581	1N914	152-0914	Raytheon	
D640	1N935A zener	152-0935A	Motorola	
D641-642-643	1N914	152-0914	Raytheon	
D650	1N5241 5% 11V zener	152-5241	Raytheon	
D651-652-653-661-662-663-				
D671-672-673-680-690:	1N914	152-0914	Raytheon	
D701-721-731-751	1N914 matched	153-0003	Raytheon	
D801	1N914	152-0914	Raytheon	
D802	1N753A 6.2V zener	152-0753A	T.I.	
D811	1N914	152-0914	Raytheon	
D812	TI55	152-0055	T.I.	
D813-821-831	1N914	152-0914	Raytheon	
D832	1N753A 6.2V zener	152-0753A	T.I.	
D840	1N914	152-0914	Raytheon	
D841	TI55	152-055	T.I.	
D842-851	1N914	152-0914	Raytheon	
D901-921-931-951	1N914 matched	153-0003	Raytheon	

Resistors

R100	68K 1/2W comp 5%	301-683	Stackpole	RC20
R101	1K 1/2W comp 5%	301-102	Stackpole	RC20
R102	10K potentiometer	311-109	Mallory	MTC4
R103	2Ω 1/2W comp 5%	301-020	Stackpole	RC20
R104	3.3K 1/2W comp 5%	301-332	Stackpole	RC20
R110	2Ω 1/2W comp 5%	301-020	Stackpole	RC20
R111	1K 1/2W comp 5%	301-102	Stackpole	RC20
R112	10K potentiometer	311-109	Mallory	MTC4
R121	1.6K 1/2W comp 5%	301-162	Stackpole	RC20
R122	12K 1/2W comp 5%	301-123	Stackpole	RC20
R123	4.3K 1/2W comp 5%	301-432	Stackpole	RC20
R124	9.1K 1/2W comp 5%	301-912	Stackpole	RC20
R131	7.5K 1/2W comp 5%	301-752	Stackpole	RC20
R132	1.6K 1/2W comp 5%	301-162	Stackpole	RC20
R142	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R143	1K 1/2W comp 5%	301-102	Stackpole	RC20
R144	845Ω 1/4W MF 1%	313-8450	Electra	MF5C
R151	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R152	3.3K 1/2W comp 5%	301-332	Stackpole	RC20
R161	649Ω 1/4W M.F. 1%	313-6490	Electra	MF5C
R171	15K 1/2W comp 5%	301-153	Stackpole	RC20
R172	20K 1/2W comp 5%	301-203	Stackpole	RC20
R173	1K 1/2W comp 5%	301-102	Stackpole	RC20
R181	2.7K 1/2W comp 5%	301-272	Stackpole	RC20
R182	8.2K 1/2W comp 5%	301-822	Stackpole	RC20
R183	1K potentiometer	311-102	Mallory	MTC4
R184	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R185	2.49K 1/4W MF 1%	313-2491	Electra	MF5C
R186	4.99K 1/4W MF 1%	313-4991	Electra	MF5C
R187	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R188	392Ω 1/4W MF 1%	313-3920	Electra	MF5C
R189	200Ω potentiometer	311-100	Mallory	MTC4
R190	3.57K 1/4W MF 1%	313-3571	Electra	MF5C
R191	7.5K 1/2W comp 5%	301-752	Stackpole	RC20
R192	200Ω potentiometer	311-100	Mallory	MTC4
R193	7.5K 1/4W MF 1%	313-7501	Electra	MF5C
R194	3.57K 1/4W MF 1%	313-3571	Electra	MF5C
R195	200Ω potentiometer	311-100	Mallory	MT5C
R201	10K 1/4W MF 1%	313-1002	Electra	MF5C
R202	2.2K 1/2W comp 5%	301-222	Stackpole	RC20
R210	10K 1/4W MF 1%	313-1002	Electra	MF5C
R211	2.2K 1/2W comp 5%	301-222	Stackpole	RC20
R212	221Ω 1/4W MF 1%	313-2210	Electra	MF5C
R213	1K 1/4W MF 1%	313-1001	Electra	MF5C
R214	3.92K 1/4W MF 1%	313-3921	Electra	MF5C
R215	1K potentiometer	311-102	Mallory	MTC4
R216	3.92K 1/4W MF 1%	313-3921	Electra	MF5C
R217	50K potentiometer	311-104	Mallory	MTC4
R218	316K 1/4W MF 1%	313-3163	Electra	MF5C
R219	500K potentiometer	311-105	Mallory	MTC4
R220	3.16M 1/2W dep cbn 1%	309-3164	Penn	FCA15
R221	5M potentiometer	311-116	Mallory	MTC4
R222	31.6M 3W dep cbn 1%	314-3165	Penn	FCA30
R223	3.48K 1/4W MF 1%	313-3481	Electra	MF5C
R231	470Ω 1/2W comp 5%	301-471	Stackpole	RC20
R232	470Ω 1/2W comp 5%	301-471	Stackpole	RC20
R233	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R234	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R235	680Ω 1/2W comp 5%	301-681	Stackpole	RC20
R236	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R237	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R238	6.8K 1/2W comp 5%	301-682	Stackpole	RC20
R250	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R251	10K 1/2W comp 5%	301-103	Stackpole	RC20
R252	120Ω 1W comp 5%	303-121	Stackpole	RC32
R253	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R255	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R256	10K 1/2W comp 5%	301-103	Stackpole	RC20
R257	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R258	120Ω 1W comp 5%	303-121	Stackpole	RC32
R260	100Ω 1/8W 1%	315-1000	IRC	6724TO
R261	100Ω 1/8W 1%	315-1000	IRC	6724TO
R262	100Ω 1/8W 1%	315-1000	IRC	6724TO
R263	100Ω 1/8W 1%	315-1000	IRC	6724TO
R264	100Ω 1/8W 1%	315-1000	IRC	6724TO
R265	100Ω 1/8W 1%	315-1000	IRC	6724TO
R266	100Ω 1/8W 1%	315-1000	IRC	6724TO
R267	100Ω 1/8W 1%	315-1000	IRC	6724TO
R268	100Ω 1/8W 1%	315-1000	IRC	6724TO
R269	100Ω 1/8W 1%	315-1000	IRC	6724TO
R270	39Ω 1/2W comp 5%	301-390	Stackpole	RC20
R271	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R272	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R273	1.5K 1/2W comp 5%	301-152	Stackpole	RC20
R274	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R275	18.2K 1/4W MF 1%	313-1822	Electra	MF5C
R276	560Ω 1/2W comp 5%	301-561	Stackpole	RC20
R277	200Ω potentiometer	311-100	Mallory	MTC4
R278	200Ω potentiometer	311-100	Mallory	MTC4
R279	200Ω potentiometer	311-100	Mallory	MTC4
R280	200Ω potentiometer	311-100	Mallory	MTC4
R281	200Ω potentiometer	311-100	Mallory	MTC4
R282	10K 1/2W comp 5%	301-103	Stackpole	RC20
R283	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R284	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R285	6.8K 1/2W comp 5%	301-682	Stackpole	RC20
R286	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R287	selected			
R288	250Ω potentiometer	311-015	Ohmite	CMJ2511
R289	2K 1/4W MF 1%	313-2001	Electra	MF5C
R291	10K 1/2W comp 5%	301-103	Stackpole	RC20
R293	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R294	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R301	12.1K 1/4W MF 1%	313-1212	Electra	MF5C
R302	1.8K 1/2W comp 5%	301-182	Stackpole	RC20
R303	100Ω potentiometer	311-099	Mallory	MTC4
R304	3.01K 1/4W MF 1%	313-3011	Electra	MF5C
R311	1K 1/4W MF 1%	313-1001	Electra	MF5C
R312	442Ω 1/4W MF 1%	313-4420	Electra	MF5C
R313	3.65K 1/4W MF 1%	313-3651	Electra	MF5C
R315	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R321	402Ω 1/4W MF 1%	313-4020	Electra	MF5C
R323	3.65K 1/4W MF 1%	313-3651	Electra	MF5C
R324	500Ω potentiometer	311-101	Mallory	MTC4
R325	4.75K 1/4W MF 1%	313-4751	Electra	MF5C
R326	4.75K 1/4W MF 1%	313-4751	Electra	MF5C
R327	500Ω potentiometer	311-101	Mallory	MTC4
R341	2.7K 1/2W comp 5%	301-272	Stackpole	RC20
R351	2.7K 1/2W comp 5%	301-272	Stackpole	RC20
R353	1K 1/2W comp 5%	301-102	Stackpole	RC20
R361	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R362	4.7K 1/2W comp 5%	301-472	Stackpole	RC20
R363	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R371	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R372	4.7K 1/2W comp 5%	301-472	Stackpole	RC20
R373	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R380	3.6K 1/2W comp 5%	301-362	Stackpole	RC20
R381	1.5K 1/2W comp 5%	301-152	Stackpole	RC20
R382	2.2K 1/2W comp 5%	301-222	Stackpole	RC20
R383	6.8K 1/2W comp 5%	301-682	Stackpole	RC20
R384	4.7K 1/2W comp 5%	301-472	Stackpole	RC20

Resistors (cont.)

R400	2.2K 1/2W comp 5%	301-222	Stackpole	RC20
R401	6.2K 1/2W comp 5%	301-622	Stackpole	RC20
R402	10K 1/2W comp 5%	301-103	Stackpole	RC20
R403	6.2K 1/2W comp 5%	301-622	Stackpole	RC20
R404	1.6K 1/2W comp 5%	301-162	Stackpole	RC20
R405	1.8K 1/2W comp 5%	301-182	Stackpole	RC20
R406	10K potentiometer	311-113	Ohmite	CMU1031
R407	10K 1/2W comp 5%	301-103	Stackpole	RC20
R420	470Ω 1/2W comp 5%	301-471	Stackpole	RC20
R421	7.5K 1/2W comp 5%	301-752	Stackpole	RC20
R430	6.2K 1/2W comp 5%	301-622	Stackpole	RC20
R431	1K 1/2W comp 5%	301-102	Stackpole	RC20
R440	2.2K 1/2W comp 5%	301-222	Stackpole	RC20
R441	7.5K 1/2W comp 5%	301-752	Stackpole	RC20
R450	2.2K 1/2W comp 5%	301-222	Stackpole	RC20
R451	7.5K 1/2W comp 5%	301-752	Stackpole	RC20
R460	6.2K 1/2W comp 5%	301-622	Stackpole	RC20
R461	3.3K 1/2W comp 5%	301-332	Stackpole	RC20
R470	39K 1/2W comp 5%	301-393	Stackpole	RC20
R481	2.7K 1/2W comp 5%	301-272	Stackpole	RC20
R482	36K 1/2W comp 5%	301-363	Stackpole	RC20
R483	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R484	100Ω potentiometer	311-099	Mallory	MTC4
R485	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R486	27K 1/2W comp 5%	301-273	Stackpole	RC20
R490	3.74K 1/4W MF 1%	313-3741	Electra	MF5C
R492	5.6K 1/2W comp 5%	301-562	Stackpole	RC20
R501	24.9K 1/4W MF 1%	313-2492	Electra	MF5C
R502	5K potentiometer	311-103	Mallory	MTC4
R503	19.1K 1/4W MF 1%	313-1912	Electra	MF5C
R504	71.5K 1/4W MF 1%	313-7152	Electra	MF5C
R505	10K potentiometer	311-109	Mallory	MTC4
R506	14.3K 1/4W MF 1%	313-1432	Electra	MF5C
R507	1K potentiometer	311-102	Mallory	MTC4
R508	35.7K 1/4W MF 1%	313-3572	Electra	MF5C
R509	5K potentiometer	311-103	Mallory	MTC4
R510	1.8M 1/2W comp 5%	301-185	Stackpole	RC20
R511	3.5M potentiometer	311-106	Mallory	MTC4
R512	71.5K 1/4W MF 1%	313-7152	Electra	MF5C
R513	36.5K 1/4W MF 1%	313-3652	Electra	MF5C
R514	2K potentiometer	311-115	Mallory	MTC4
R515	10K potentiometer	311-326	Ohmite	CB1031
R516	10K 1/4W MF 1%	313-1002	Electra	MF5C
R517	82Ω 1/2W comp 5%	301-820	Stackpole	RC20
R518	6.19K 1/4W MF 1%	313-6191	Electra	MF5C
R519	820Ω 1/2W comp 5%	301-821	Stackpole	RC20
R520	6.19K 1/4W MF 1%	313-6191	Electra	MF5C
R521	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R522	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R523	6.8M 1/2W comp 5%	301-685	Stackpole	RC20
R531	100Ω potentiometer	311-099	Mallory	MTC4
R532	4.7K 1/2W comp 5%	301-472	Stackpole	RC20
R533	10K 1/2W comp 5%	301-103	Stackpole	RC20
R534	5.6K 1/2W comp 5%	301-562	Stackpole	RC20
R541	6.8M 1/2W comp 5%	301-685	Stackpole	RC20
R542	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R543	270Ω 1/2W comp 5%	301-271	Stackpole	RC20
R544	31.6K 1/4W MF 1%	313-3162	Electra	MF5C
R545	10K 1/2W comp 5%	301-103	Stackpole	RC20
R546	1.5M 1/2W comp 5%	301-155	Stackpole	RC20
R551	6.19K 1/4W MF 1%	313-6191	Electra	MF5C
R552	7.5K 1/2W comp 5%	301-752	Stackpole	MF5C
R553	100Ω potentiometer	311-099	Mallory	MTC4
R554	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R555	6.19K 1/4W MF 1%	313-6191	Electra	MF5C
R556	820Ω 1/2W comp 5%	301-821	Stackpole	RC20
R561	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R562	10K 1/4W MF 1%	313-1002	Electra	MF5C
R563	500Ω potentiometer	311-101	Mallory	MTC4
R564	10K potentiometer	311-109	Mallory	MTC4
R565	8.45M 1/2W dep cbn 1%	301-8454	Penn	FCA15
R566	845K 1/4W MF 1%	313-8453	Electra	MF5C
R567	84.5K 1/4W MF 1%	313-8452	Electra	MF5C
R568	1M potentiometer	311-111	Mallory	MTC4
R569	100K potentiometer	311-110	Mallory	MTC4
R570	10K potentiometer	311-109	Mallory	RTC4
R571	100K potentiometer	311-110	Mallory	MTC4
R572	10K potentiometer	311-109	Mallory	MTC4
R573	10K potentiometer	311-109	Mallory	MTC4
R574	28K 1/4W MF 1%	313-2802	Electra	MF5C
R575	10K 1/2W comp 5%	301-103	Stackpole	RC20
R576	82.5K 1/4W MF 1%	313-8252	Electra	MF5C
R581	10K 1/4W MF 1%	313-1002	Electra	MF5C
R582	270Ω 1/2W comp 5%	301-271	Stackpole	RC20
R583	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R584	10K potentiometer	311-109	Mallory	MTC4
R585	10K 1/2W comp 5%	301-103	Stackpole	RC20
R586	1M potentiometer	311-111	Mallory	MTC4
R587	100K potentiometer	311-110	Mallory	MTC4
R588	10K potentiometer	311-109	Mallory	MTC4
R589	100K potentiometer	311-110	Mallory	MTC4
R590	10K potentiometer	311-109	Mallory	MTC4
R591	10K potentiometer	311-109	Mallory	MTC4
R592	28K 1/4W MF 1%	313-2802	Electra	MF5C
R594	8.45M 1/2W dep cbn 1%	309-8454	Penn	FCA15
R595	845K 1/4W MF 1%	313-8453	Electra	MF5C
R596	10K 1/2W comp 5%	301-103	Stackpole	RC20
R597	82.5K 1/4W MF 1%	313-8252	Electra	MF5C
R600	3.92K 1/4W MF 1%	313-3921	Electra	MF5C
R601	200Ω potentiometer	311-100	Mallory	MTC4
R602	1.30K 1/4W MF 1%	313-1301	Electra	MF5C
R610	3.92K 1/4W MF 1%	313-3921	Electra	MF5C
R611	1K 1/2W comp 5%	301-102	Stackpole	RC20
R612	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R613	100Ω potentiometer	311-099	Mallory	MTC4
R614	3.9K 1/2W comp 5%	301-392	Stackpole	RC20
R620	910Ω 1/2W comp 5%	301-911	Stackpole	RC20
R621	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R622	3K 1/2W comp 5%	301-302	Stackpole	RC20
R630	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R631	3K 1/2W comp 5%	301-302	Stackpole	RC20
R640	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R641	121Ω 1/4W MF 1%	313-1210	Electra	MF5C
R642	221Ω 1/4W MF 1%	313-2210	Electra	MF5C
R643	267Ω 1/4W MF 1%	313-2670	Electra	MF5C
R650	750Ω 1/2W comp 5%	301-751	Stackpole	RC20
R651	1K 1/2W comp 5%	301-102	Stackpole	RC20
R652	121Ω 1/4W MF 1%	313-1210	Electra	MF5C
R653	825Ω 1/4W MF 1%	313-8250	Electra	MF5C
R654	221Ω 1/4W MF 1%	313-2210	Electra	MF5C
R655	3.32K 1/4W MF 1%	313-3321	Electra	MF5C
R656	267Ω 1/4W MF 1%	313-2670	Electra	MF5C
R657	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R660	465Ω 1/4W MF 1%	313-4750	Electra	MF5C
R661	562Ω 1/4W MF 1%	313-5620	Electra	MF5C
R662	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R663	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R665	33Ω 1/2W comp 5%	301-330	Stackpole	RC20
R670	3.92K 1/4W MF 1%	313-3921	Electra	MF5C
R671	475Ω 1/4W MF 1%	313-4750	Electra	MF5C
R672	8.25K 1/4W MF 1%	313-8251	Electra	MF5C
R673	562Ω 1/4W MF 1%	313-5620	Electra	MF5C
R674	2.21K 1/4W MF 1%	313-2211	Electra	MF5C
R675	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R676	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R681	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R682	4.7K 1/2W comp 5%	301-472	Stackpole	RC20
R683	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R691	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R692	4.7K 1/2W comp 5%	301-472	Stackpole	RC20
R693	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R694	33Ω 1/2W comp 5%	301-330	Stackpole	RC20
R695	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R701	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R702	1K potentiometer	311-107	Ohmite	CMU1021
R703	619Ω 1/4W MF 1%	313-6190	Electra	MF5C
R704	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R705	560Ω 1/2W comp 5%	301-561	Stackpole	RC20
R706	10K potentiometer	311-109	Mallory	MTC4
R711	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R712	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R721	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R722	220Ω 2W comp 5%	305-221	Stackpole	RC42
R723	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R731	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R732	825Ω 1/4W MF 1%	313-8250	Electra	MF5C
R733	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R734	619Ω 1/4W MF 1%	313-6190	Electra	MF5C
R741	3.32K 1/4W MF 1%	313-3321	Electra	MF5C
R742	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R743	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R751	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R752	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R753	220Ω 2W comp 5%	305-221	Stackpole	RC42
R754	1.82K 1/4W MF 1%	313-1821	Electra	MF5C
R755	20K potentiometer	311-320	Beckman	78LR20K
R756	12K 1/2W comp 5%	301-123	Stackpole	RC20
R801	2.7K 1/2W comp 5%	301-272	Stackpole	RC20
R802	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R803	1.8K 1/2W comp 5%	301-182	Stackpole	RC20
R804	2.2K 1/2W comp 5%	301-222	Stackpole	RC20
R810	2Ω 1/2W comp 5%	301-020	Stackpole	RC20
R811	1K 1/2W comp 5%	301-102	Stackpole	RC20
R812	12K 1/2W comp 5%	301-123	Stackpole	RC20
R813	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R814	10K 1/2W comp 5%	301-103	Stackpole	RC20
R820	10Ω 1/2W comp 5%	301-100	Stackpole	RC20
R821	4.7K 1/2W comp 5%	301-472	Stackpole	RC20
R822	220Ω 2W comp 5%	305-221	Stackpole	RC42
R823	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R824	1.1K 1/4W MF 1%	313-1101	Electra	MF5C
R825	1.82K 1/4W MF 1%	313-1820	Electra	MF5C
R826	39Ω 1/2W comp 5%	301-390	Stackpole	RC20
R831	150Ω 1/2W comp 5%	301-151	Stackpole	RC20
R832	1.3K 1/2W comp 5%	301-132	Stackpole	RC20
R833	2.7K 1/2W comp 5%	301-272	Stackpole	RC20

Resistors (cont.)

R840	2Ω 1/2W comp 5%	301-020	Stackpole	RC20
R841	1.2K 1/2W comp 5%	301-122	Stackpole	RC20
R842	12K 1/2W comp 5%	301-123	Stackpole	RC20
R843	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R844	10K 1/2W comp 5%	301-103	Stackpole	RC20
R850	10Ω 1/2W comp 5%	301-100	Stackpole	RC20
R851	1K potentiometer	311-107	Ohmite	CMU1021
R852	15Ω 1/2W comp 5%	301-150	Stackpole	RC20
R853	220Ω 2W comp 5%	305-221	Stackpole	RC42
R854	4.7K 1/2W comp 5%	301-472	Stackpole	RC20
R855	10Ω 1/2W comp 5%	301-100	Stackpole	RC20
R856	330Ω 1/2W comp 5%	301-331	Stackpole	RC20
R901	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R902	619Ω 1/4W MF 1%	313-6190	Electra	MF5C
R903	1K potentiometer	311-107	Ohmite	CMU1021
R904	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R905	10Ω 1/2W comp 5%	301-100	Stackpole	RC20
R911	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R912	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R921	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R922	220Ω 2W comp 5%	305-221	Stackpole	RC42
R923	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R924	1K 1/4W MF 1%	313-1001	Electra	MF5C
R925	10Ω 1/2W comp 5%	301-100	Stackpole	RC20
R931	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R932	619Ω 1/4W MF 1%	313-6190	Electra	MF5C
R933	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R934	365Ω 1/4W MF 1%	313-3650	Electra	MF5C
R935	560Ω 1/2W comp 5%	301-561	Stackpole	RC20
R936	10K potentiometer	311-109	Mallory	MTC4
R937	10Ω 1/2W comp 5%	301-100	Stackpole	RC20
R941	1.1K 1/4W MF 1%	313-1101	Electra	MF5C
R942	100Ω 1/2W comp 5%	301-101	Stackpole	RC20
R943	47Ω 1/2W comp 5%	301-470	Stackpole	RC20
R944	2.7K 1/2W comp 5%	301-272	Stackpole	RC20
R945	20K potentiometer	311-320	Beckman	78LR20K
R951	22Ω 1/2W comp 5%	301-220	Stackpole	RC20
R952	5.62K 1/4W MF 1%	313-5621	Electra	MF5C
R953	220Ω 2W comp 5%	305-221	Stackpole	RC42
R954	10Ω 1/2W comp 5%	301-100	Stackpole	RC20

Transistors

Q100	2N4898 PNP	156-4898	Motorola
Q110	2N4910 NPN	156-4910	Motorola
Q120	2N4121 PNP	156-4121	Fairchild
Q130	TIS87 NPN	156-0087	T.I.
Q140	2N4910 NPN	156-4910	Motorola
Q150	2N4898 PNP	156-4898	Motorola
Q160	TIS87 NPN	156-0087	T.I.
Q170	2N4121 PNP	156-4121	Fairchild
Q180	TIS87 NPN	156-0087	T.I.
Q190	2N4121 PNP	156-4121	Fairchild
Q200	F5085A matched P channel FET	157-0005	Union Carbide
Q210	F5085A matched P channel FET	157-0005	Union Carbide
Q230	CA3030 IC	158-0008	RCA
Q250	TIS87	156-0087	T.I.
Q255	2N4121 PNP	156-4121	Fairchild
Q260	CA3030 IC	158-0008	RCA
Q280	TIS87 NPN	156-0087	T.I.
Q290	2N4121 PNP	156-4121	Fairchild
Q300	2N4121 PNP	156-4121	Fairchild
Q310	2N4121 matched PNP	157-4121	Fairchild
Q320	2N4121 matched PNP	157-4121	Fairchild
Q340, 350, 360:	TIS87 PNP	156-0087	T.I.
Q370	2N4121 PNP	156-4121	Fairchild
Q380	TIS87 NPN	156-0087	T.I.
Q400, 420, 430:	TIS87	156-0087	T.I.
Q440	MPS5643	156-5643	Motorola
Q450, 460, 470, 480, 490:	TIS87	156-0087	T.I.
Q500	2N4045 dual NPN	156-4045	Union Carbide
Q530	TIS87 NPN	156-0087	T.I.
Q540	2N4121 PNP	156-4121	Fairchild
Q550-560	2N4121 PNP, matched	157-4121	Fairchild
Q580	TIS87 NPN	156-0087	T.I.
Q600, 610	TIS87 NPN	156-0087	T.I.
Q620 through Q660:	2N4121	156-4121	Fairchild
Q670	TIS87 NPN	156-2219	T.I.
Q680	2N2219 NPN	156-2219	T.I.
Q690	2N2905 PNP	156-2905	T.I.
Q700	2N2219 NPN matched	157-0007	T.I.
Q710	2N2905 PNP matched	157-0007	T.I.
Q800	TIS87 NPN	156-0087	T.I.
Q810	2N4121 PNP	156-4121	Fairchild
Q820	2N2219 NPN	156-2219	T.I.
Q830	2N4121 PNP	156-4121	Fairchild
Q840	TIS87 NPN	156-0087	T.I.
Q850	2N2905 PNP	156-2905	T.I.
Q900	2N2219 NPN matched	157-0007	T.I.
Q910	2N2905 PNP matched	157-0007	T.I.
Q930	2N2905 PNP matched	157-0007	T.I.
Q940	2N2219 NPN matched	157-0007	T.I.

Switches

S100	Power, SPDT	260-103	Alco	MST 105D
S200	Decade 6p 2-11 pos s	260-089	Oak	399763K
S250	Multiplier	260-249	Exact	
S300	Offset 3p 3pos s	260-090	Oak	½" sub-min
S400	Mode 4p 4pos ns	260-084	Ledex	751081-001
S401	man.pushbutton SPDT	260-086	Alco	MSP 105F
S500	Sweep 3pdt	260-087	Alco	MST 305D
S501	VCF mode	260-084	Ledex	751081-001
S560	Symmetry 3p 3pos s	260-090	Oak	½" sub-min
S700	Amp 2 1-p 11-pos ns	260-085	Ledex	751082-001
S810	Sq Amp 1-p 11-pos	260-085	Ledex	751082-001
S900	Amp 1 1-p 11-pos	260-085	Ledex	751082-001

Connectors, Fuse, Lamp, Transformer

J180	connector wh/blk	355-536	Knobex	820-45
J181	connector wh/blk	355-536	Knobex	820-45
J380	connector BNC	131-046	Bendix	667-6
J400	connector Elco	131-031	Elco	02-027-013-5-200
J401	connector BNC	131-046	Bendix	667-6
J500	connector BNC	131-046	Bendix	667-6
J501	connector Elco	131-032	Elco	02-038-013-5-200
J721	connector BNC	131-046	Bendix	667-6
J821	connector BNC	131-046	Bendix	667-6
J921	connector BNC	131-046	Bendix	667-6
P100	power cord	161-016	Miller	E-1894
P400	connector Elco	131-029	Elco	02-027-114-3-200
P501	connector Elco	131-030	Elco	02-038-114-3-200
F100	fuse 1/2 amp SloBlo 3AG	159-024	Littlefuse	
DS100	lamp, neon	136-045	Alco	BNF2
T100	transformer	120-030	Sartron	4184

SECTION 7

CIRCUIT DIAGRAMS

7.1.0	BLOCK DIAGRAM
7.1.1	P. C. ASSEMBLY, MAIN BOARD
7.1.2	P. C. ASSEMBLY, VCF BOARD
7.1.3	P. C. ASSEMBLY, GATE LOCKOUT
7.2.0	POWER SUPPLY
7.3.0	INTEGRATOR
7.4.0	X10 AMPLIFIER
7.5.0	LEVEL DETECTOR
7.6.0	VCF AMPLIFIER
7.7.0	LOCKOUT AMPLIFIER
7.8.0	SINE SHAPER
7.9.0	AMPLIFIER 2
7.10.0	SQUARE AMPLIFIER
7.11.0	AMPLIFIER 1
7.12.0	TIMING AND FEEDBACK CIRCUITRY

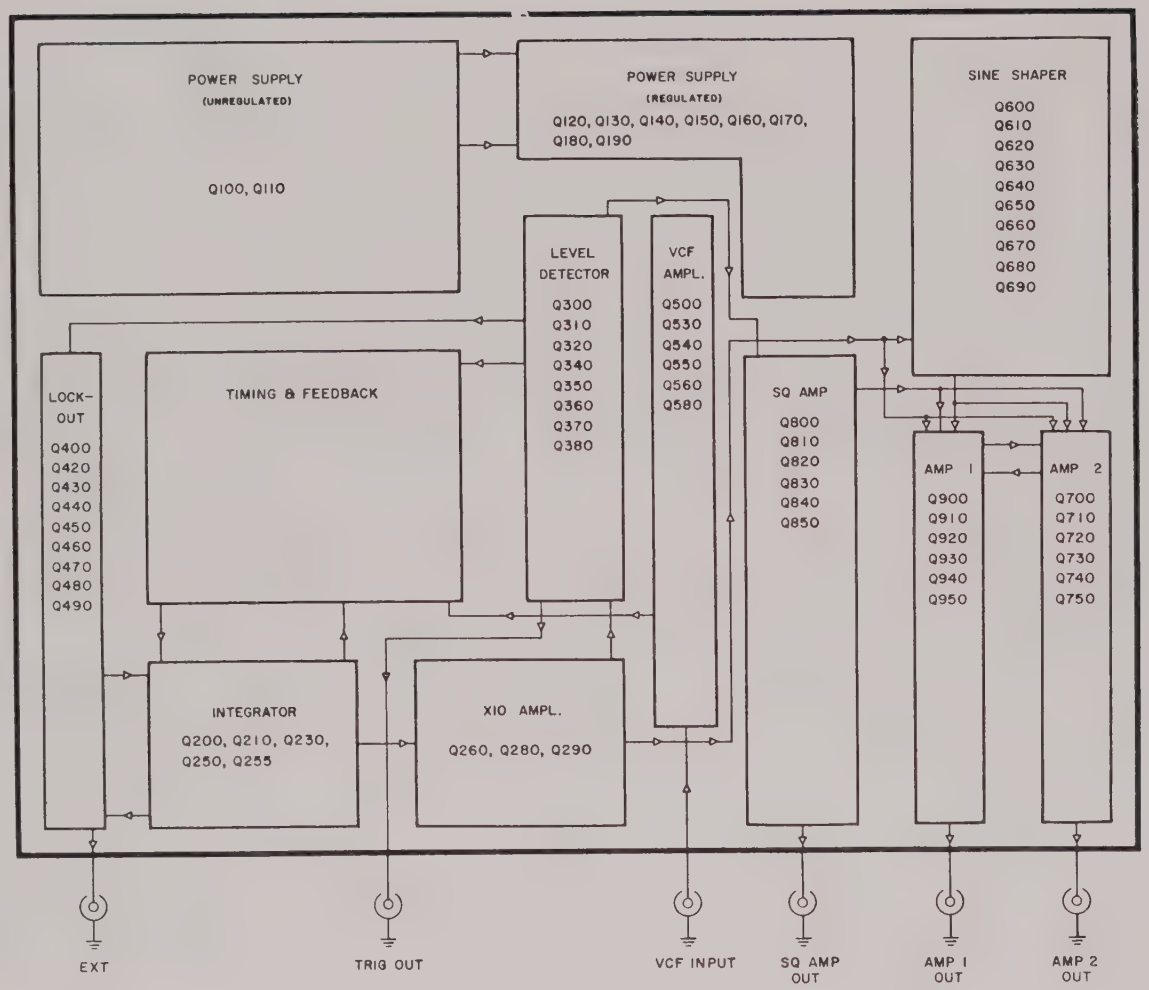
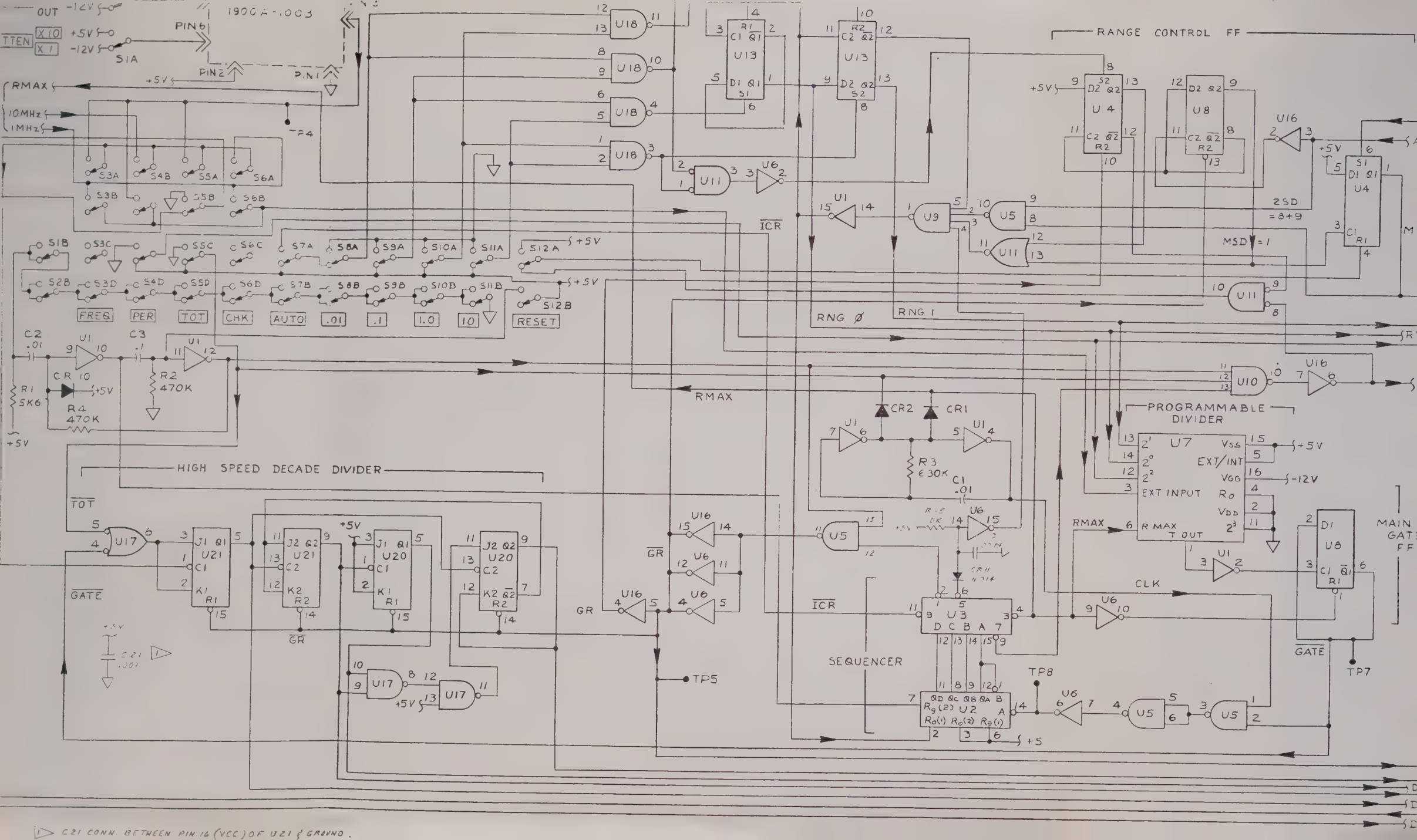
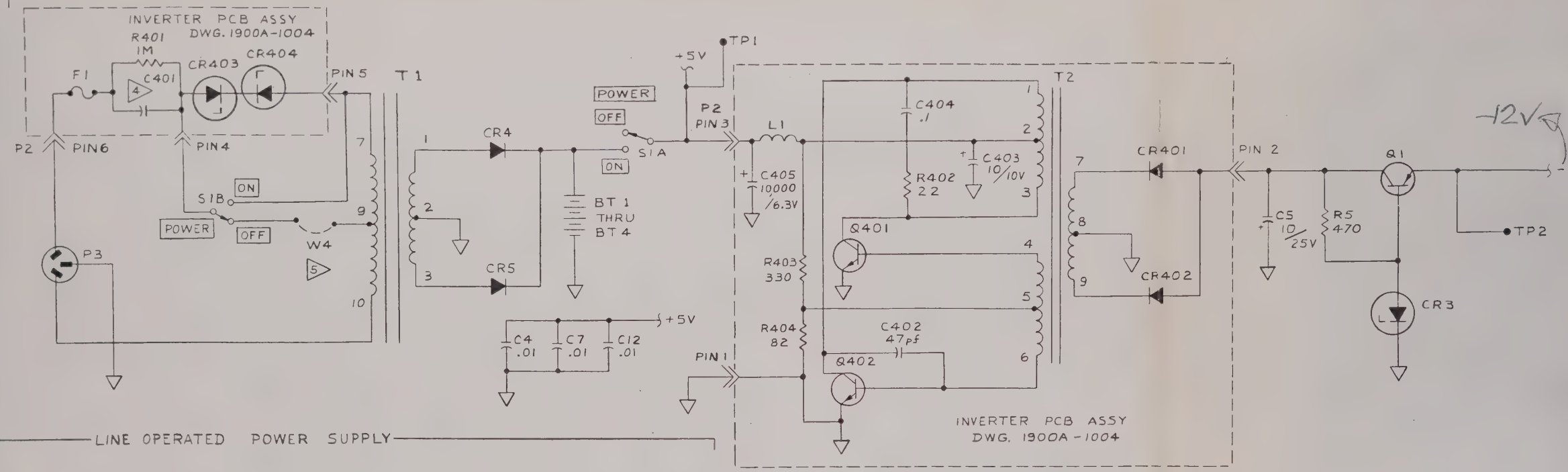


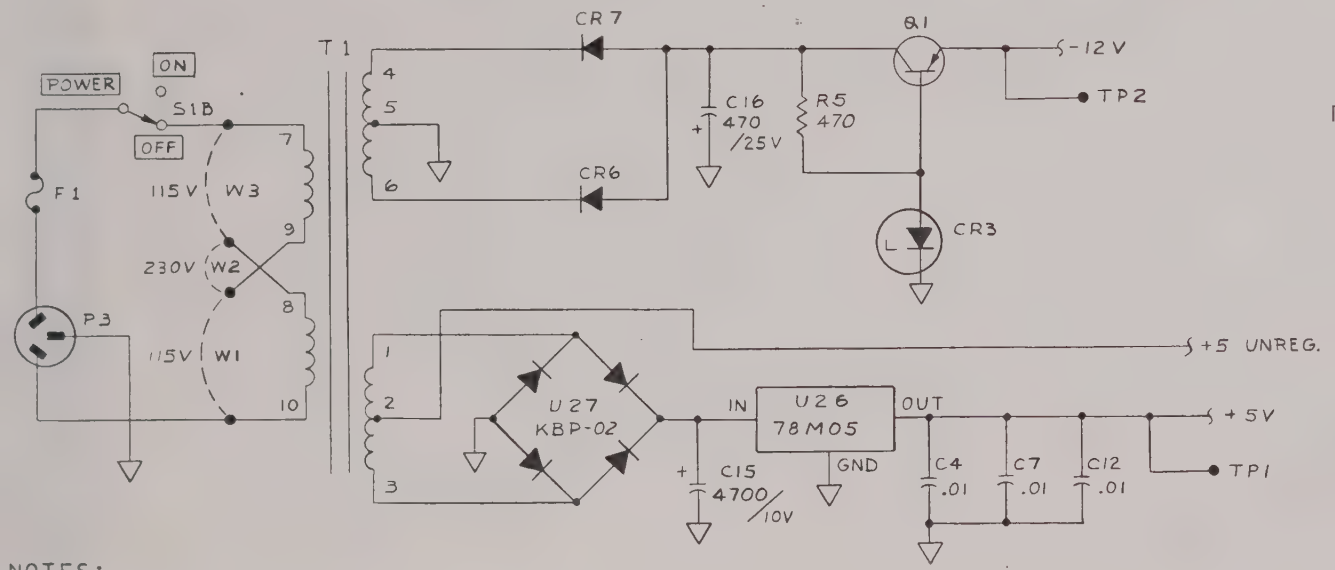
FIG. 7.1.0
BLOCK DIAGRAM


RANGE CONTROL FF
HIGH SPEED DECADE DIVIDER
PROGRAMMABLE DIVIDER
SEQUENCER
MAIN GATE FF
FREQ
PER
TOT
CHK
AUTO
.01
.1
1.0
10
RESET
RMAX
RNG Ø
RNG 1
ICR
GR
GATE
CLK
TP5
TP7
TP8
+5V
-12V
MSD = 1
2SD = 8+9
1900A-1003
C21 CONN. BETWEEN PIN 16 (VCC) OF U21 & GROUND.

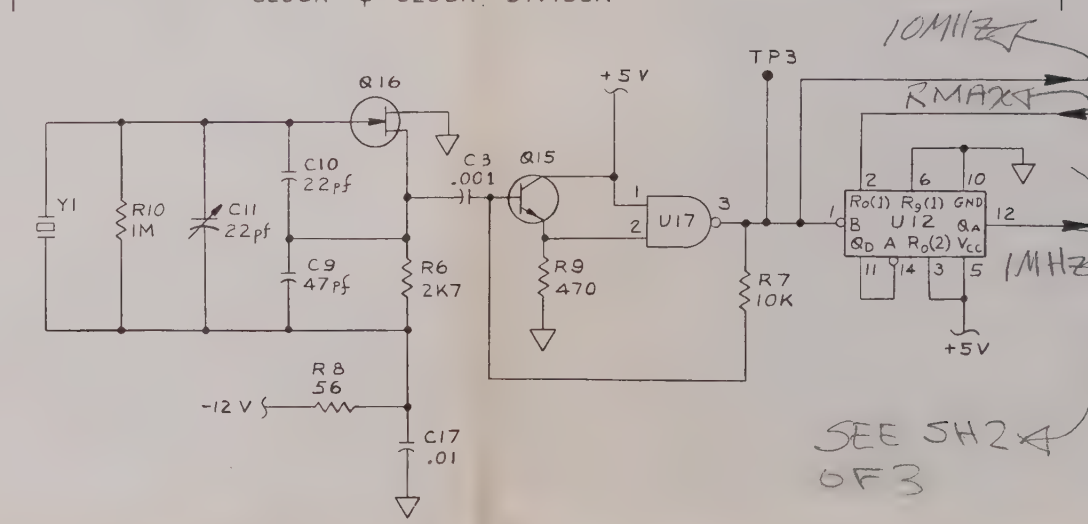
BATTERY OPERATED POWER SUPPLY



LINE OPERATED POWER SUPPLY



CLOCK & CLOCK DIVIDER



NOTES:

1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5% C.C. UNLESS OTHERWISE NOTED.
2. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE NOTED.
3. ALL SWITCHES ARE IN RELEASE POSITION.

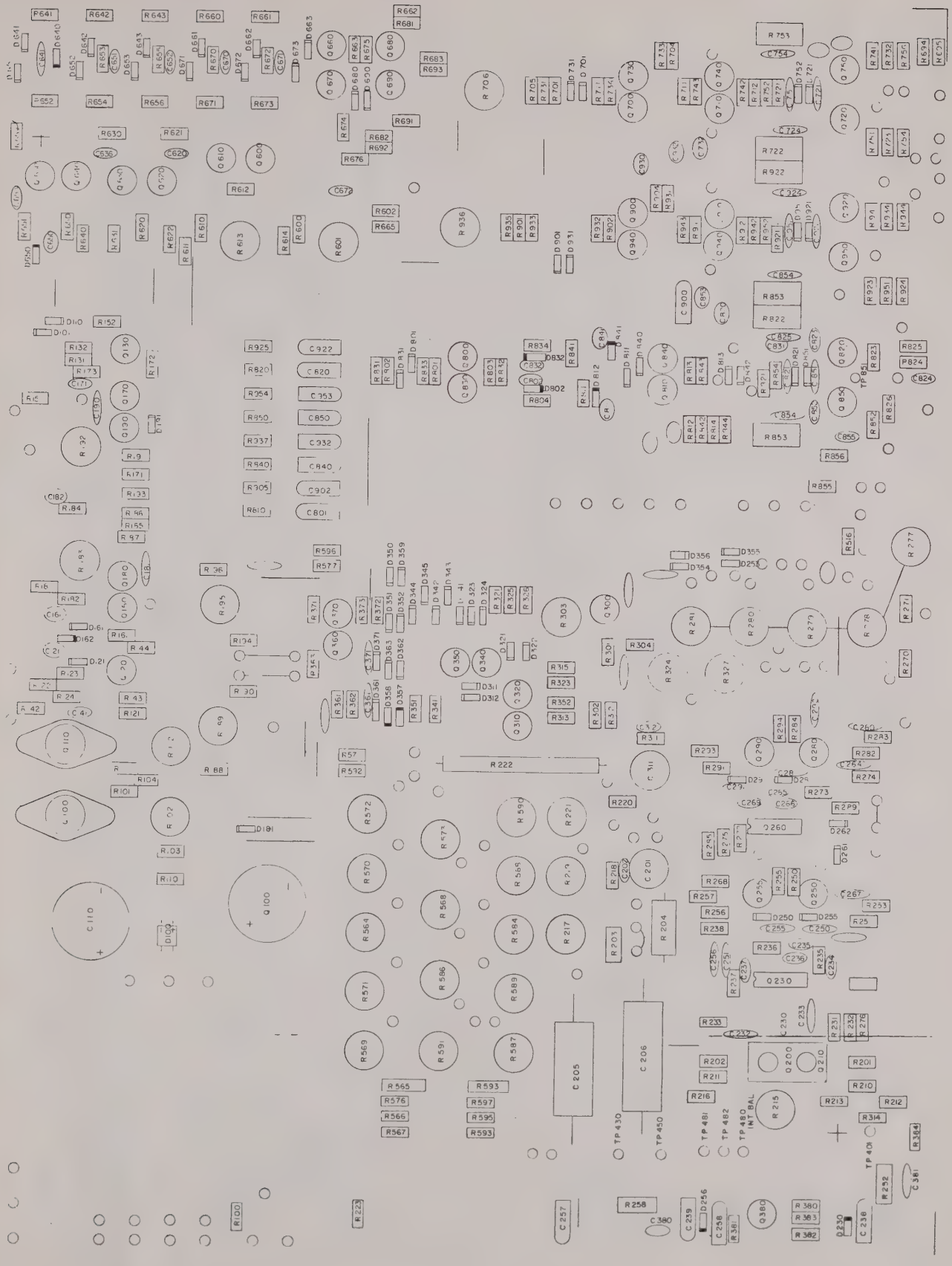


FIG 7.1.1

P. C. ASSEMBLY BOARD MODELS 500-B, 503-B, 504-B, 505-B

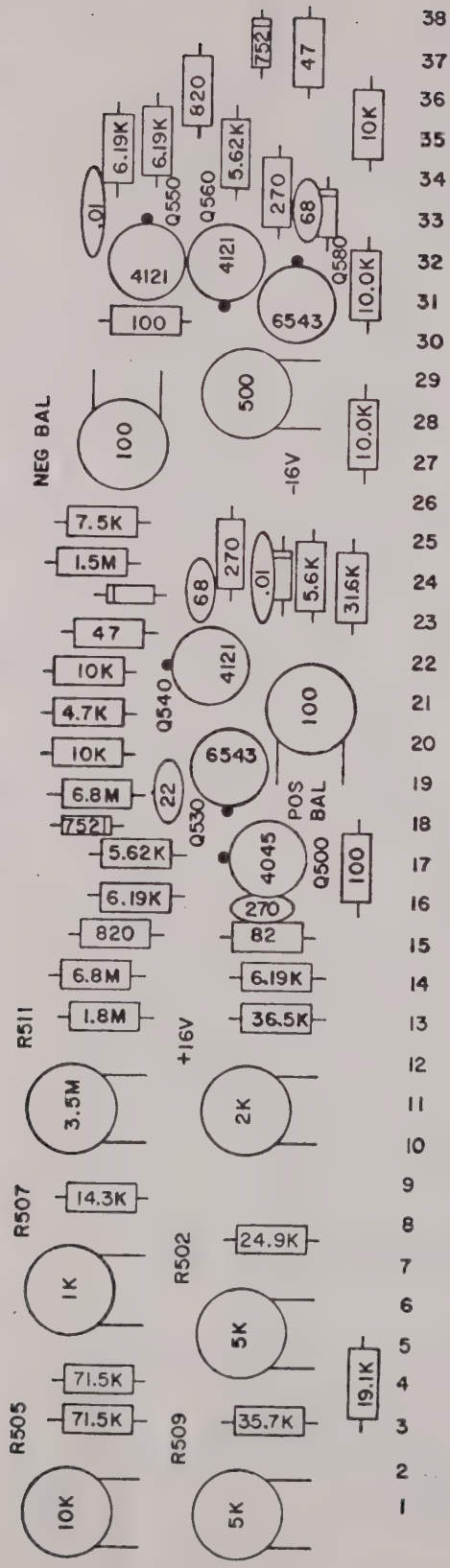


FIG 7.1.2
P.C. ASSEMBLY VCF BOARD

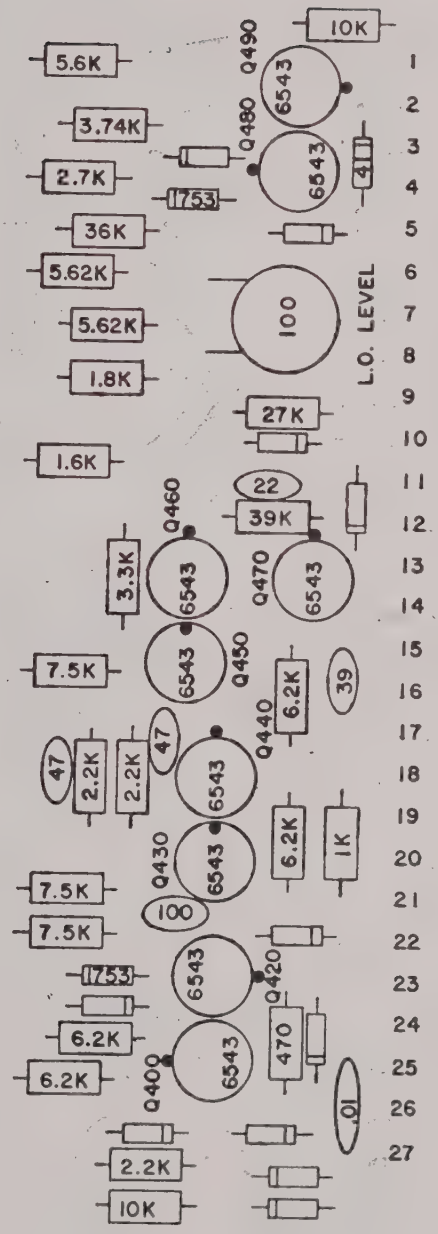
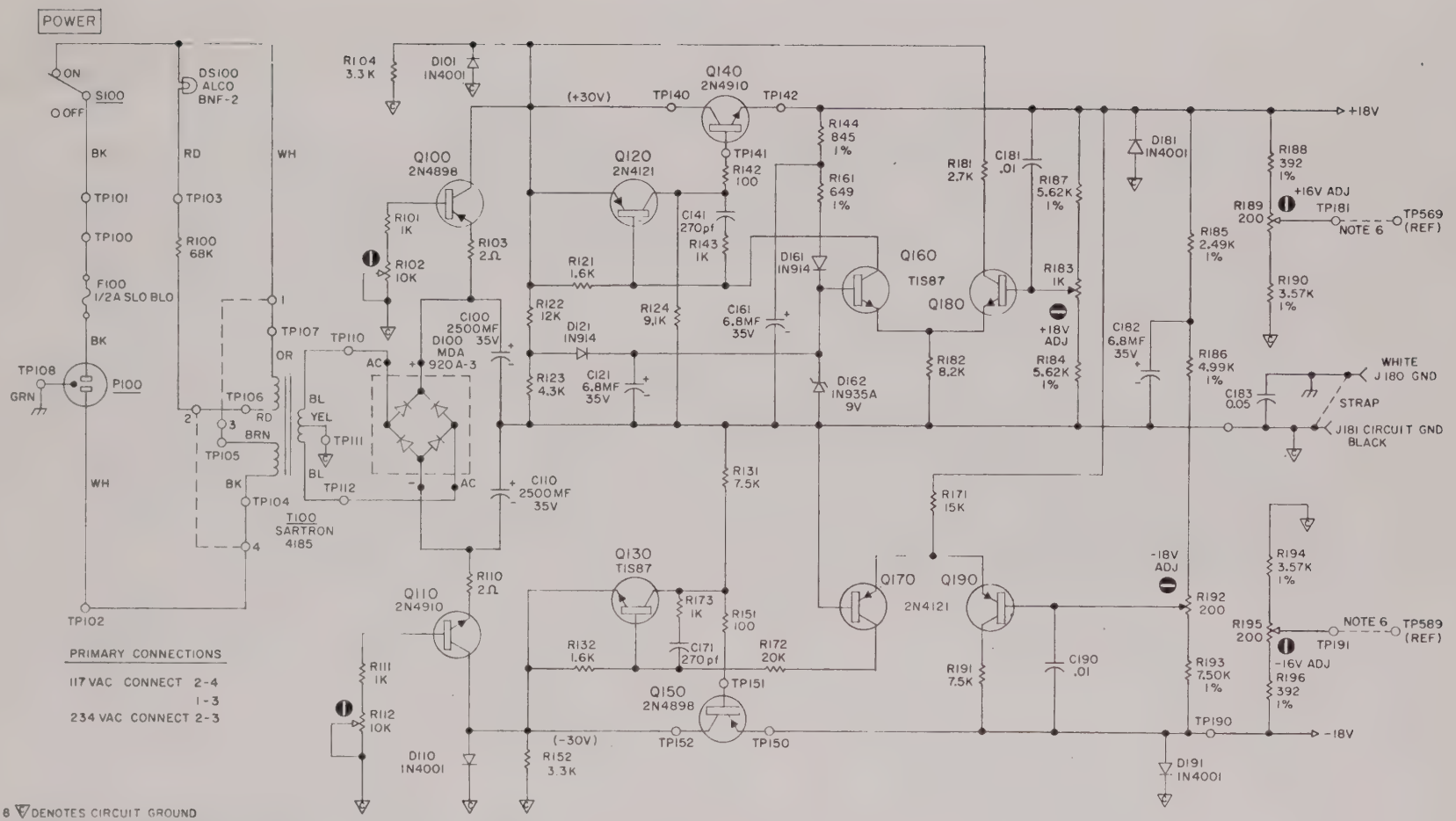
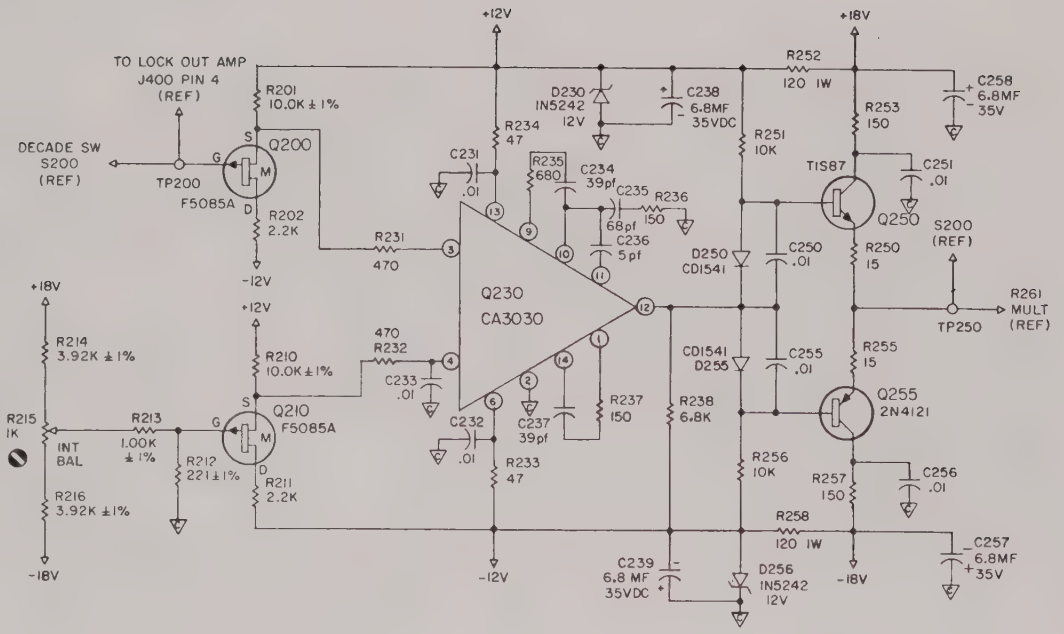


FIG 7.1.3
P.C. ASSEMBLY GATE LOCKOUT BOARD



8 ▽ DENOTES CIRCUIT GROUND
7 /// DENOTES CHASSIS GROUND
6 JUMPER USED IN MODELS 500A, 504A ONLY
5 TIS87 PIN CONFIGURATION. (BOTTOM VIEW) E C B
4 ALL 1% RESISTORS. 1/4W
3 ALL RESISTORS 1/2W 5%
2 ALL CAPACITORS MARKED IN MF
1 ALL RESISTORS MARKED IN OHMS
NOTES: UNLESS OTHERWISE INDICATED

FIG. 7.2.0
POWER SUPPLY



6 ▽ DENOTES CHASSIS GROUND

5 TIS87 PIN CONFIGURATION (BOTTOM VIEW)

4 ALL CAPACITORS IN MF

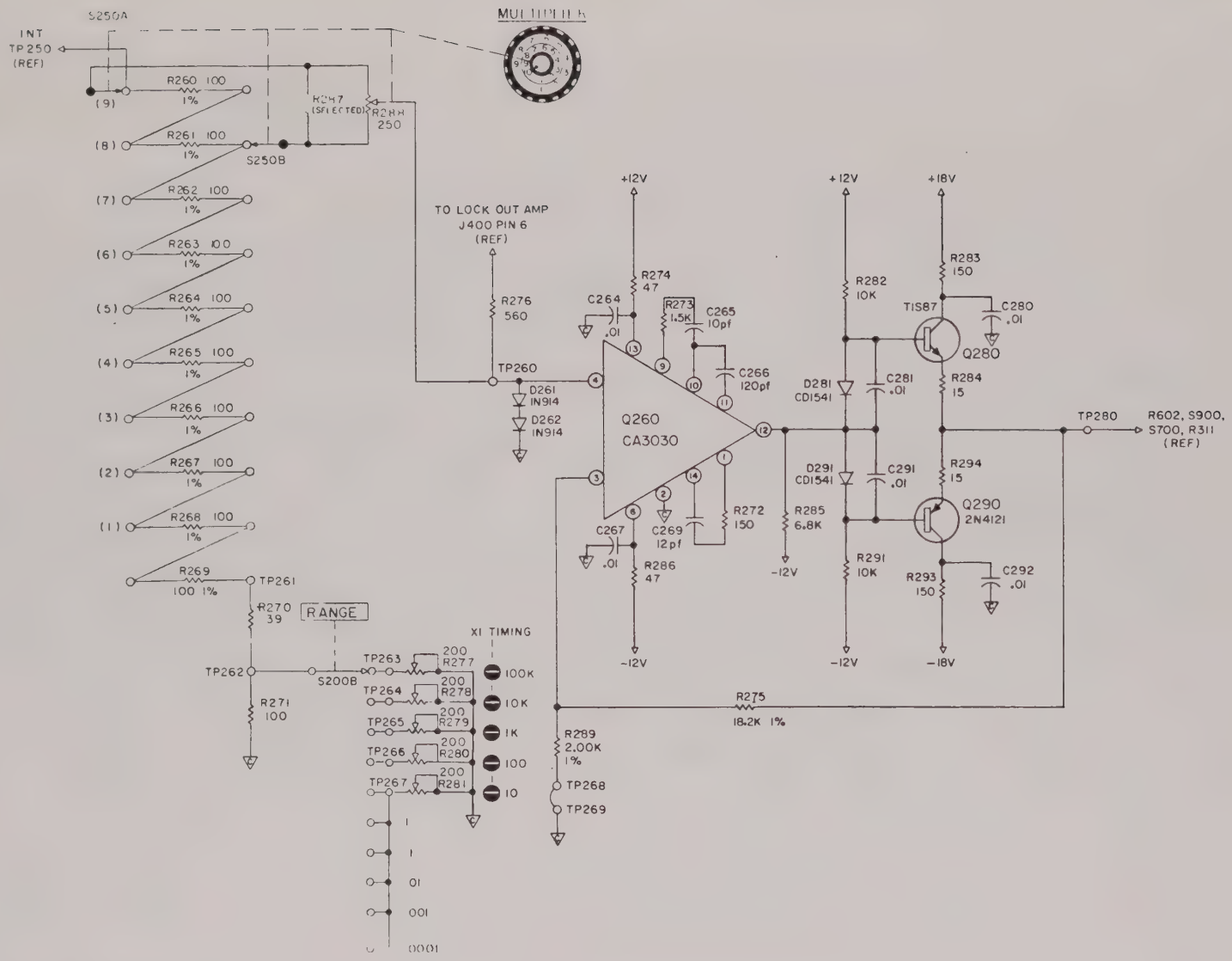
3 ALL 1% RESISTORS 1/4W

2. ALL RESISTORS 1/2W ±5%

1. ALL RESISTORS MARKED IN OHMS

NOTES: UNLESS OTHERWISE INDICATED

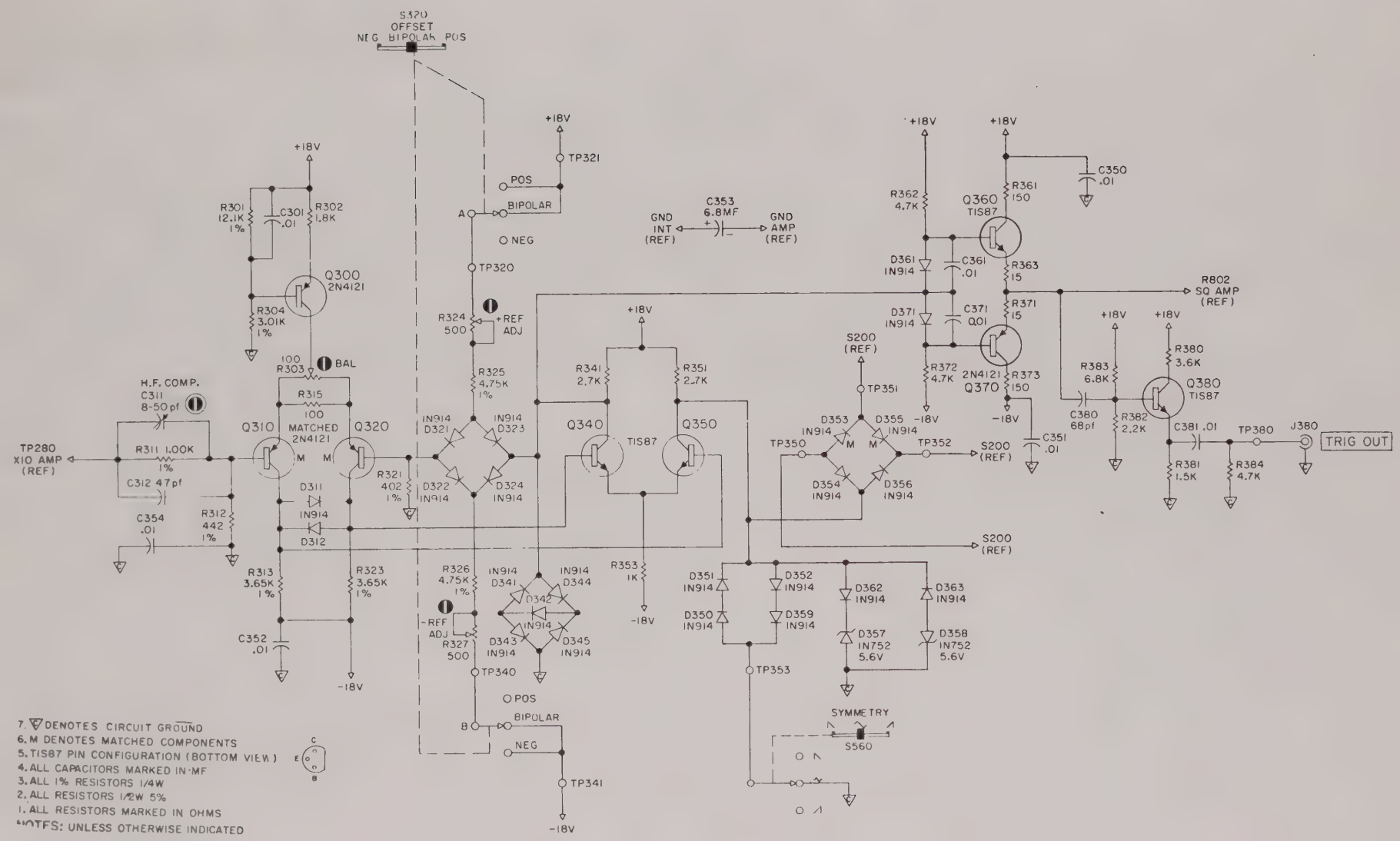
FIG. 7.3.0
INTEGRATOR



6. ▽ DENOTES CIRCUIT GROUND
5. TIS87 PIN CONFIGURATION (BOTTOM VIEW)
4. ALL CAPACITORS IN MF
3. ALL 1% RESISTORS 1/4 W
2. ALL RESISTORS 1/2 W 5%
1. ALL RESISTORS MARKED IN OHMS

NOTES: UNLESS OTHERWISE INDICATED

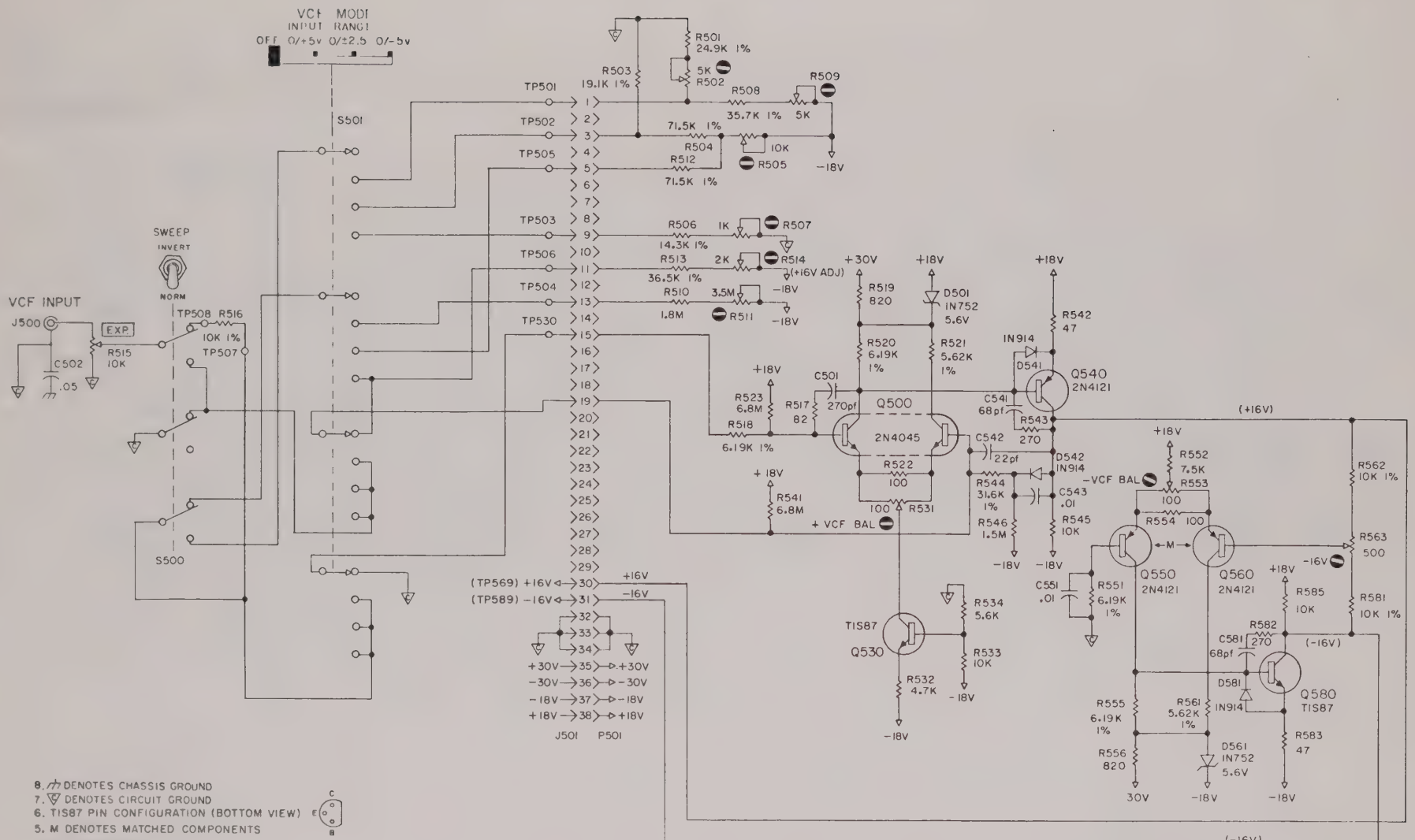
FIG. 7.4.0
X10 AMPLIFIER



7. ⏚ DENOTES CIRCUIT GROUND
6. M DENOTES MATCHED COMPONENTS
5. TIS87 PIN CONFIGURATION (BOTTOM VIEW)
4. ALL CAPACITORS MARKED IN MF
3. ALL 1% RESISTORS 1/4W
2. ALL RESISTORS 1/2W 5%
1. ALL RESISTORS MARKED IN OHMS

NOTES: UNLESS OTHERWISE INDICATED

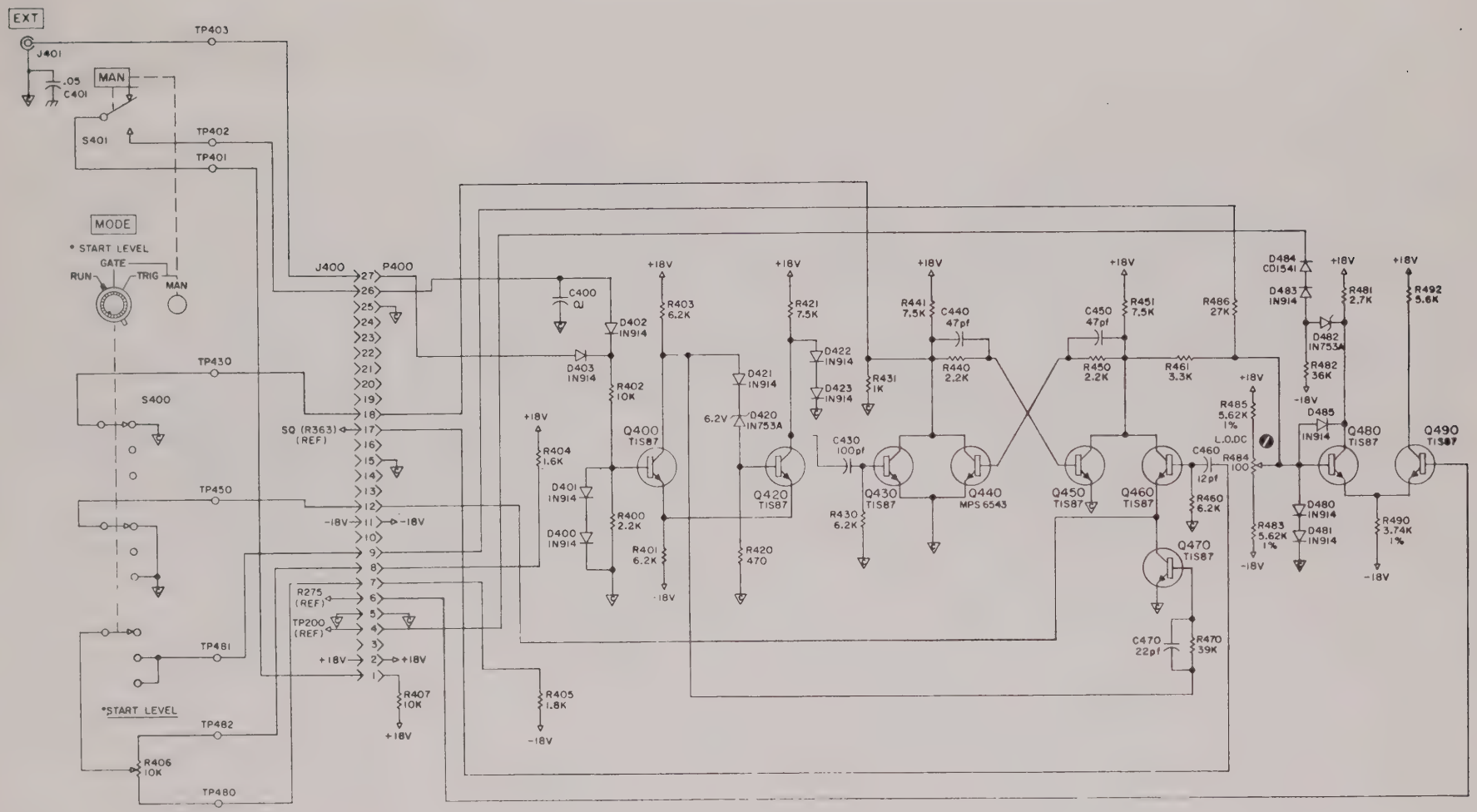
FIG. 7.5.0
LEVEL DETECTOR



8. ⏚ DENOTES CHASSIS GROUND
7. ▽ DENOTES CIRCUIT GROUND
6. TIS87 PIN CONFIGURATION (BOTTOM VIEW)
5. M DENOTES MATCHED COMPONENTS
4. ALL CAPACITORS IN MF
3. ALL 1% RESISTORS 1/4W
2. ALL RESISTORS 1/2W 5%
1. ALL RESISTORS MARKED IN OHMS

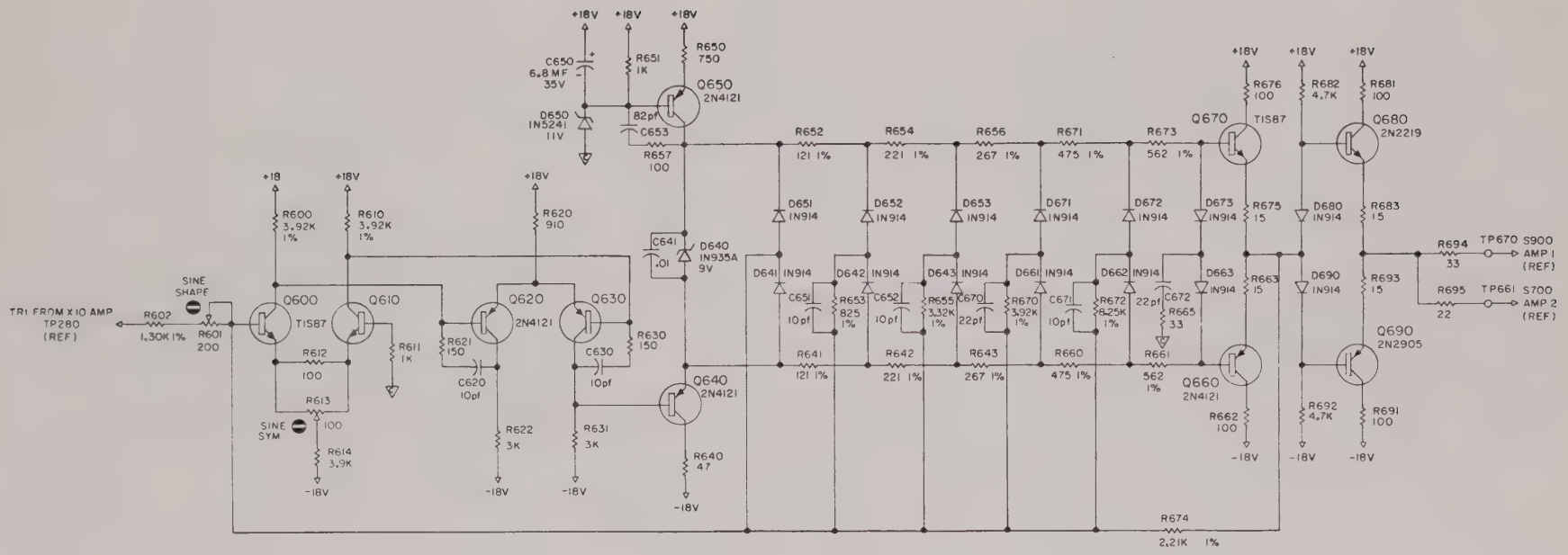
NOTES: UNLESS OTHERWISE INDICATED

FIG. 7.6.0
VCF AMPLIFIER



7 ⏚ DENOTES CHASSIS GROUND
6 ▽ DENOTES CIRCUIT GROUND
5 TIS87 PIN CONFIGURATION (BOTTOM VIEW)
4 ALL CAPACITORS MARKED IN MF
3 ALL 1% RESISTORS 1/4W
2 ALL RESISTORS 1/2W 5%
1 ALL RESISTORS MARKED IN OHMS
NOTES UNLESS OTHERWISE INDICATED

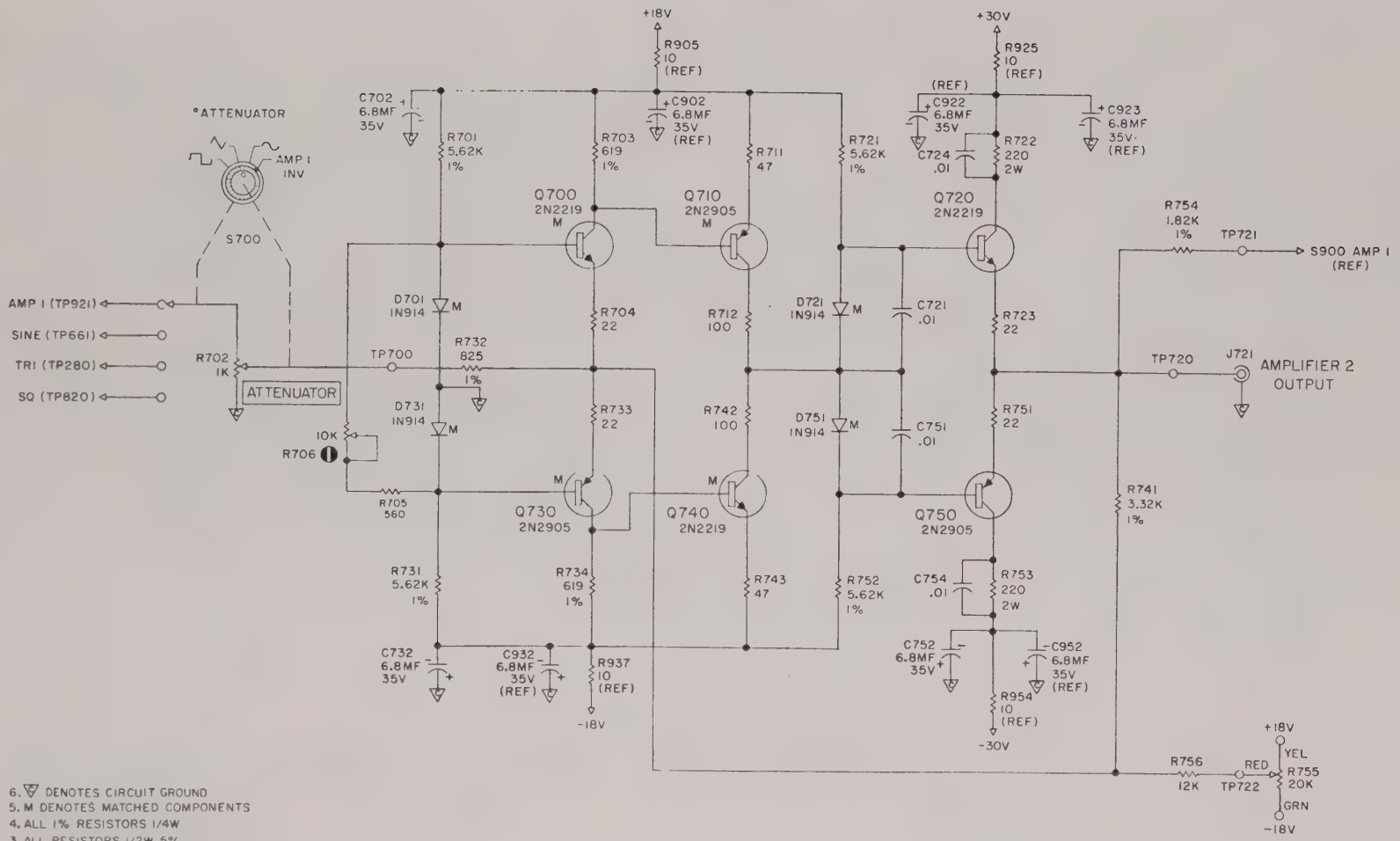
FIG. 7.7.0
LOCKOUT AMPLIFIER



6. ▽ DENOTES CIRCUIT GROUND
5. TIS87 PIN CONFIGURATION (BOTTOM VIEW)
4. ALL CAPACITORS IN MF
3. ALL 1% RESISTORS 1/4W
2. ALL RESISTORS 1/2W ±5%
1. ALL RESISTORS MARKED IN OHMS

NOTES: UNLESS OTHERWISE INDICATED

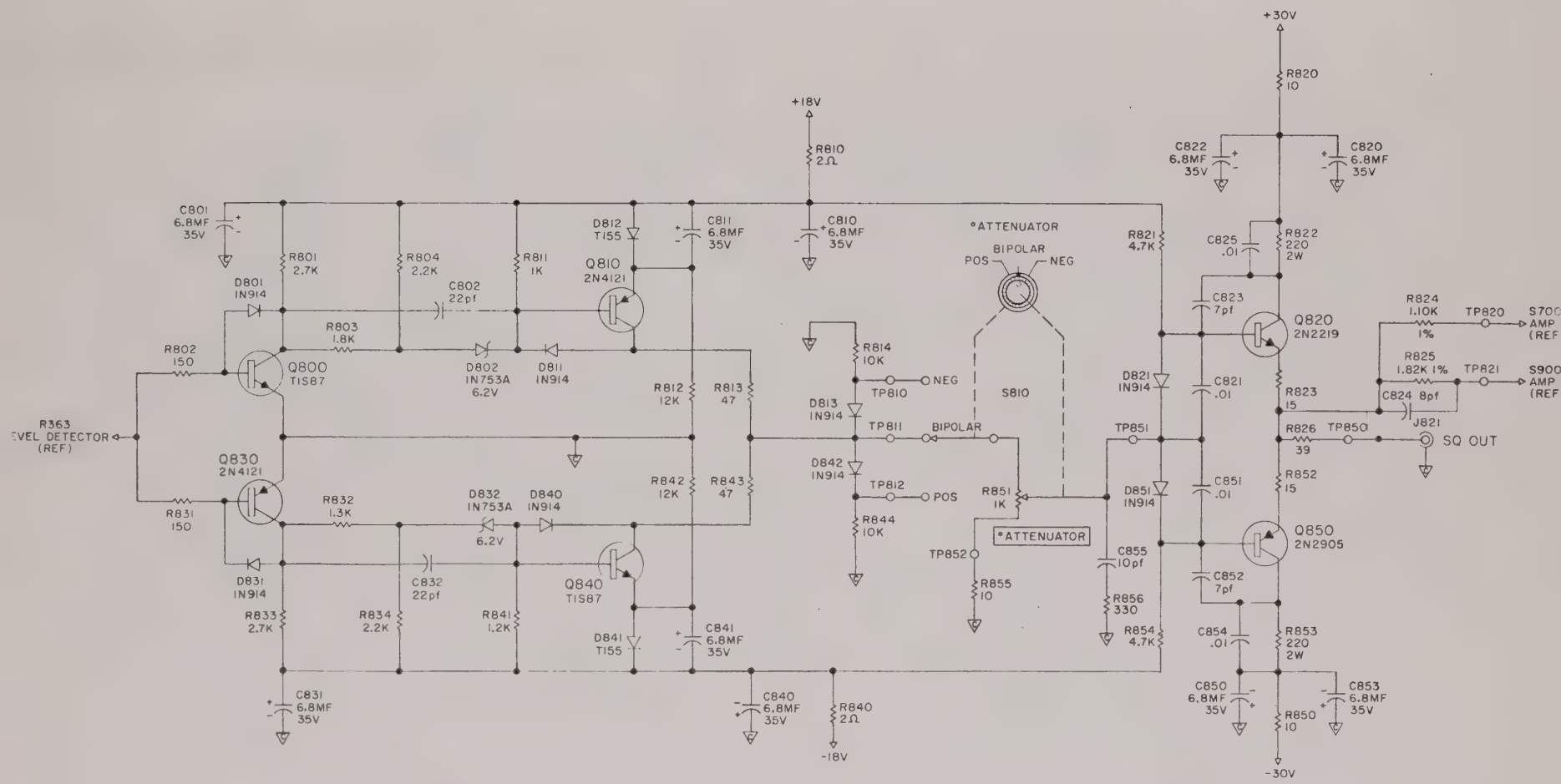
FIG. 7.8.0
SINE SHAPER



6. ▽ DENOTES CIRCUIT GROUND
5. M DENOTES MATCHED COMPONENTS
4. ALL 1% RESISTORS 1/4W
3. ALL RESISTORS 1/2W 5%
2. ALL CAPACITORS MARKED IN MF
1. ALL RESISTORS MARKED IN OHMS

NOTES: UNLESS OTHERWISE INDICATED

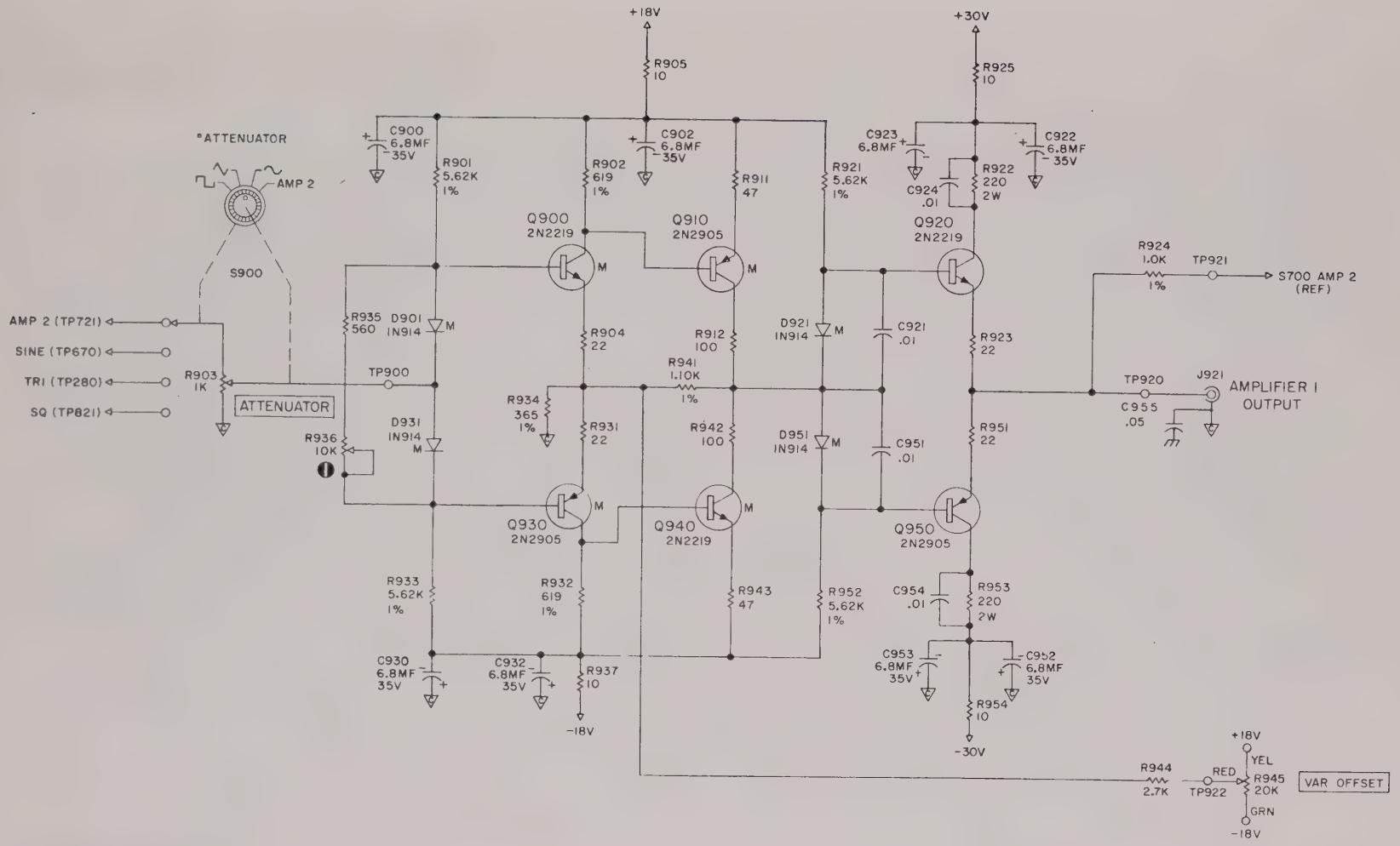
FIG. 7.9.0
AMP 2



6. ▽ DENOTES CIRCUIT GROUND
5. TIS87 PIN CONFIGURATION (BOTTOM VIEW)
4. ALL CAPACITORS MARKED IN MF
3. ALL 1% RESISTORS 1/4W
2. ALL RESISTORS 1/2W 5%
1. ALL RESISTORS MARKED IN OHMS

NOTES: UNLESS OTHERWISE INDICATED

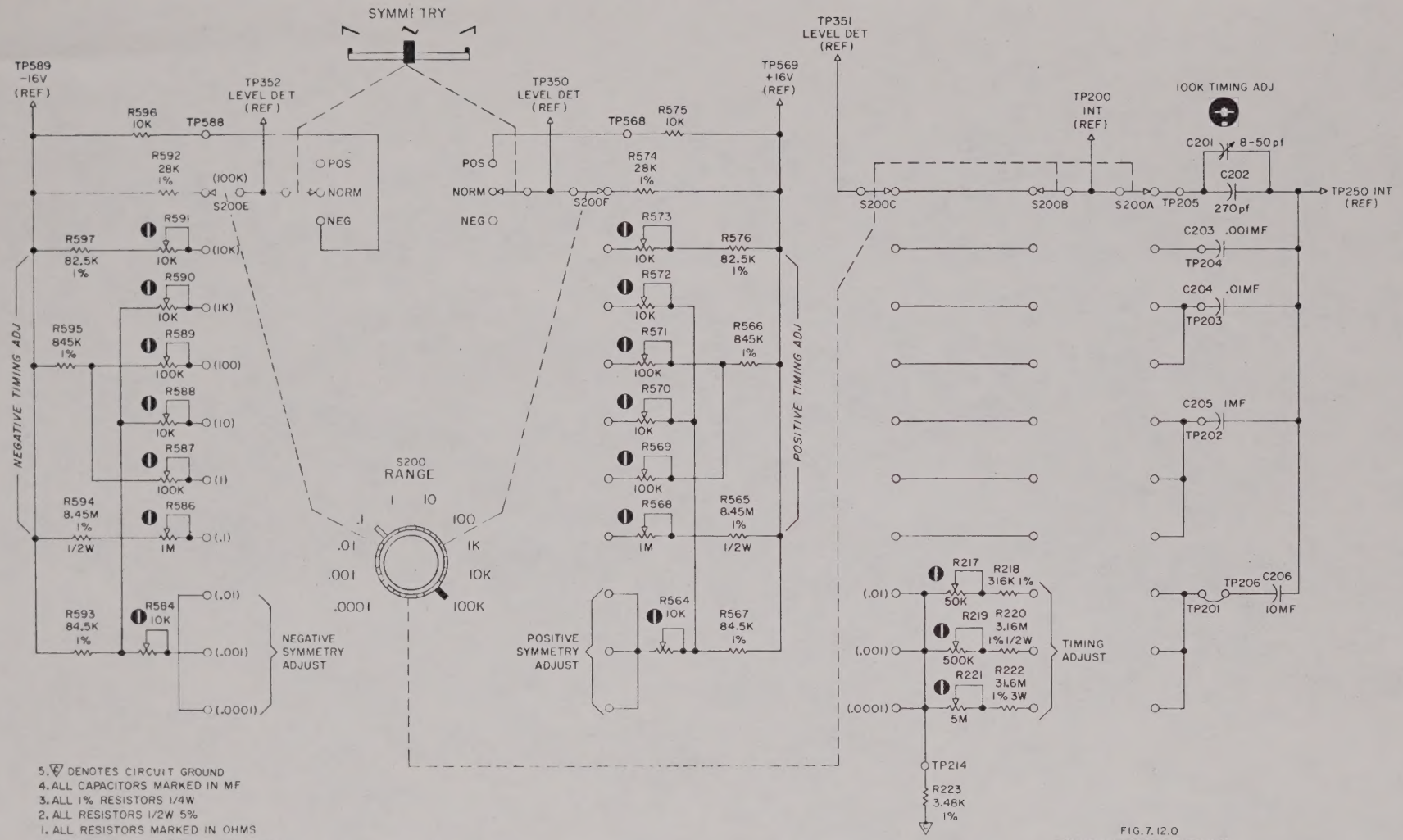
FIG. 7.10.0
SQURE AMPLIFIER



7. ⏚ DENOTES CHASSIS GROUND
6. ▽ DENOTES CIRCUIT GROUND
5. M DENOTES MATCHED COMPONENTS
4. ALL 1% RESISTORS 1/4W
3. ALL RESISTORS 1/2W 5%
2. ALL CAPACITORS MARKED IN MF
1. ALL RESISTORS MARKED IN OHMS

NOTES: UNLESS OTHERWISE INDICATED

FIG. 7.11.0
AMP 1



5. ▽ DENOTES CIRCUIT GROUND
4. ALL CAPACITORS MARKED IN MF
3. ALL 1% RESISTORS 1/4W
2. ALL RESISTORS 1/2W 5%
1. ALL RESISTORS MARKED IN OHMS

NOTES: UNLESS OTHERWISE INDICATED

FIG. 7.12.0
TIMING & FEEDBACK CIRCUITRY